Rapid Transit.

BY PROF. L. M. HAUPT, MEM. ENGINEER'S CLUB OF PHILA.

(*Read May 17th*, 1884.)

An article appeared quite recently in one of our local papers containing this statement: "The Enormous Growth of Travel on city railways in New York, especially since the construction of elevated railroads, is little short of marvellous." This was followed by a quotation of statistics from the letter of John I. Davenport, Esq., dated March 29th, 1884, addressed to Mr. Melville C. Smith, President of the Broadway Underground Railway. As this letter is deserving of more than ordinary consideration, I desire to call your attention to a few of its prominent features and to draw some additional conclusions therefrom, with special reference to our own city.

TOPOGRAPHY.

It considers first the topography of New York City or Manhattan Island, which is about nine and a half miles in length from Castle Garden to the Sixth Avenue crossing of the Harlem River, and about two miles in average width. The area within these limits, as measured by the planimeter, being 18¾ sq. miles. The island is surrounded by navigable rivers, which, with its water connections, extending as far west as Minnesota, have given it great commercial supremacy. Originally the surface was rugged and rocky, with numerous swampy depressions, which it has been difficult and expensive to grade and drain.

As the opponents of Rapid Transit in Philadelphia have made the *topography* of the two cities the main point in the arguments *pro* and *con*, it may not be amiss to compare conditions. Philadelphia, like New York, is situated between two navigable rivers, but which, for the built-up portion, are a little farther apart than are those of that city. Instead of being an island it is a peninsula. West Philadelphia, in its topography, may be compared to Brooklyn; and Camden to Jersey City. Both cities adjoin a foreign State. If a plan of Manhattan Island be laid over one of Philadelphia, drawn on the same scale, so that the Battery coincides with League Island, and Sixth Avenue with Broad Street, the Harlem River at Sixth Avenue (150th Street) will be found above Erie Avenue, and the whole of this part of New York will lie between these north and south limits and the two rivers, with about an equal area to spare. Or, if the plan of New York be shifted so as to bring the City Hall up to Market Street, the Battery will be found at Washington Avenue, and Fourteenth Street at Girard Avenue, while the Harlem will just touch the county line road. If then, there is a necessity for Rapid Transit in New York, there is a greater necessity for it in Philadelphia, for *its need is proportional to the extent of surface and the distance of the residents from the business centers.*

New Yorkers have the additional great advantage that their lines of communication are nearly all direct, while Philadelphians, in crossing the city diagonally, must be continually turning aside to go around the corner.

COMMERCIAL SUPREMACY.

Mr. Henry C. Gardner, in an address to real estate owners in New York, in 1870, said: "Commercial prosperity is secured and retained only by constant enterprise. Seventy years ago (1800) Philadelphia was the first commercial city on this continent. She contained a population of 70,287,* while that of her greatest rival was only 60,529. But New York added to the advantages of her harbor those of the Erie Canal, and thus secured the Western trade and with it commercial supremacy. For years she experienced the flood tide of success; but in 1860 the ebb began, since which time her decline has been far more rapid than her advancement.

* This was within the old city limits.

POPULATION.

Between 1800 and 1860 the increase of population in New York as compared with that of the United States was as 253 to 100, while from 1860 to 1870 the figures were reversed. In Brooklyn the population in 1860 was 266,661, and in 1870 it was 396,661, showing a gain of 130,000, which was 17,328 more than that of New York for the same period. The ratio of increase being as 48.75 per cent. to 13.84 per cent. In 1840 there were only 14,342 persons living above Fourteenth Street, when the city limits extended only to Twenty-sixth Street. In 1860 the population above Fourteenth Street had increased to 313,494, while that of the Third Ward, which is west of the City Hall, had decreased from 11,581 to 3,757, a loss of 7,724 or about 70 per cent.

Between 1840 and 1860 the total population increased 500,959 or 160 per cent., yet the Second and Third Wards decreased 187 per cent. The part above Fourteenth Street increased in these twenty years over 658 per cent. against 160 per cent. for the entire city. Street railways were introduced in 1852, and in 1860 there were six lines in operation, carrying for that year 36½ millions of passengers.

During the next five years six more lines were added, and in 1865 these twelve lines carried over 82 millions of passengers, yet the movement was confined to the old limits at Eighty-sixth Street, and during the next five years no additional lines were built, although the patronage in 1870 exceeded 115 millions.

The ratio of increase of population for the sixty years prior to 1860 was 28 per cent. every five years, 5.6 per cent. a year, which, had it remained constant until 1870, would have given a population then of 1,334,973, an increase of 520,404, whereas the actual increase was only 112,672, showing a loss of 407,732, a population greater than that of the city of Brooklyn, all of which would have been located in the upper part of the city but for lack of transportation facilities. The mere pecuniary loss to the real estate interests from this cause is estimated at $500,000,000, the revenues from which, @ 2 per cent., would have been $10,000,000.

TIME LIMITS OF TRAVEL IN NEW YORK.

Thus it is seen that up to 1860 New York increased rapidly in wealth and population, when she outgrew her limits and overflowed into Brooklyn and New Jersey, the stages and street cars being incapable of making better time and thus extending their distances. The limit of travel, as measured by time and convenience, in New York was then about four miles, and the business center being at Wall Street, made it more expeditious and certain to reside even at some distance across the rivers than at the upper end of the island. Measured by time alone Harlem was 34 miles from the City Hall and Elizabeth, N. J., but 14. The convenience and certainty of travel by steam roads as contrasted with the sufferings and delays by the horse cars, in winter especially placed an effectual barrier across the northward current and diverted it into the eastern and western channels.

DENSITY AND DISTRIBUTION OF POPULATION.

"In 1860 the population of New York was 813,669, of which number 468,549 or 57.6 per cent. resided below Fourteenth Street, in a district covering but 3¾ sq. miles of the 38.11 included in city limits. In 1870 the population was 942,292, of whom 497,289 or 52.8 per cent., a little more than half, lived within the above limits; and in 1880, of 1,206,299 persons only 542,251 or 45 per cent., considerably less than half, remained in the aforesaid district. This diminution of 12.6 per cent. shows the combined relief afforded by the surface and elevated roads to this densely populated district, and is its own commentary on the inadequacy of the provision. New York waited too long for relief.

In December, 1864, a census of New York showed 495,592 persons in 111,000 families (4½ to a family) living in 15,309 tenements and cellars. An average of 32.37 persons or 7¼ families to a house. Again in 1869 there were 483,492 persons in 113,405 families occupying 14,872 tenements, an average of 31½ persons to a house, and very nearly the same condition was found to exist in 1880, when there was an average of 31 to each tenement.

In Philadelphia, in 1870, there were 674,022 persons housed in 112,366 dwellings, giving 6 to each house. In 1860 the number was 6.3 to each house, and in 1880, 5.8. Here there are two extreme cases to which it may be said the same rule will not apply, but we will see on examination that it does, for "It's a poor rule that wont work both ways." New York is so densely inhabited, not because it has no Rapid Transit facilities, but because they are wholly inadequate to provide for the wants of the community; it needs more for the health and morality of its citizens, and Philadelphia with her 910,707[1] inhabitants, spread out over 129.3 square miles of area, needs them for concentration and economy of time and energy. It is a question of time *vs.* health, for if our facilities of transit do not keep pace with our increase of population we will soon be corralled by time limits, and the density, mortality and immorality of the population must increase correspondingly. In New York 75 per cent. of all the deaths occur in the tenement houses or hospitals, where in some wards, notably the Tenth, Eleventh, Thirteenth, Fourteenth and Seventeenth, the population ranges from 432, 353, 349, 314 to 309 to the acre, while the best authorities place the maximum density compatible with health at 100 to the acre.

In Phildaelphia, in 1880, the Third Ward was peopled at the rate of 150 to the acre, and the Fourteenth was nearly as dense. The Fourth, Seventeenth, Twelfth, Thirteenth, Seventh and Tenth are all above the maximum limit (in the order given). These wards lie south of Pine Street north of Vine, as stated in a previous paper on Intercommunications in Cities (Vol. II, 1881), where the subject of the distribution of the population is more fully treated, and some important deductions given, which need not now be repeated. It will be sufficient to indicate these overcrowded zones by a shade on the map, thus exhibiting their relative positions and extent, and showing where relief is desired.

Theoretical Consideration of the Relative Rates of Travel, Whether on Foot, by Street Cars, by Elevated or Underground Roads, or by Ordinary Surface Railroads, as Affecting the Areas Available for a Salubrious Distribution of Population.

As the velocities of travel are equal to the distances divided by the times, or $v = \frac{d}{t}$, let us assume a uniform value for t, variable values for v and determine the resulting values for d, and, as, a fair basis of comparison, let us make *the time limit a half hour*, as being the average time which the business or laboring classes of a community require in going to, or in returning from, their occupations. The value of t will then be 30 minutes. In this time and at the ordinary velocities the distances traversed will be

	Miles.		Min.
For pedestrians,	2	or at the rate of 1 mile in	15
" horse cars,	3	" " "	10
" cable system,	3	" " "	10
" elevated,	6	" " "	5
" underground or way trains,	10	" " "	3

It will probably meet the case fully to assume that each person traveling by any of the above means moves over the entire distance, that is, that a pedestrian makes a round trip of 4 miles from the perimeter to the business center and back; hence the limits of a city where the residents go on foot would have a radius of *two miles* or an area of 12½ square miles if people could move across it radially.

[1] Estimated for 1884.

Under similar conditions the street car or cable city would be limited by a radius of *three miles* or an area of 28¼ square miles; the elevated railroad city of *six miles* with an area of 113,04 square miles, or *four times that of the street car*, and the underground railroad city a radius of *ten miles* or an area of 314 square miles, These theoretical limits, except the last, are shown in the map by the several circles described from Sixth and Market Streets as a business centre.

Practically, however, as there are no radial streets in the greater portion of these areas, and passengers are thus compelled to zigzag across the city diagonally, the areas will become squares with their diagonals on the principal axes, and the practical limits will be as follows:

Pedestrians,	diag.	4	miles, area	8.00	sq. miles.
Horse or cable,	"	6	" "	18.00	"
Elevated,	"	12	" "	72.00	"
Underground,	"	20	" "	200.00	

whilst the total area of the city is 129.3 square miles.

With the business centre at sixth and Market Streets however, the plan of *this* city does not admit of unlimited expansion in all directions, as the Delaware River will cut off the eastern angles of the squares, thus reducing the practically available areas to about 6¼ square miles or 5 per cent. of the whole area for pedestrians;[2] 13¼ square miles or 10¼ per cent. for street cars, and 50 square miles or 44 per cent. of the entire area for elevated roads. From the above data it is evident that a rate of travel of 6 miles per hour is *altogether inadequate* to render available the territory of a city having an area of 129 square miles.

VERIFICATION.

To verify the above assumptions as to position and distances the present limit of the built up portion of the city has been indicated on the map, from information furnished by the Registry Department, and by comparing it with the square representing the street car city, it will be seen that the half hour limits of street car travel have already been reached and in some instances passed, and that the depots and stables are close to these limits, being generally inside.

Where there are diagonal avenues, as in the case of Ridge, Lancaster and Woodland Avenues, and the oblique streets in the north-eastern section of the city, the improvements have slightly surpassed the limits, proving conclusively the effect of a reduction of time and distance in extending and rendering more valuable the taxable property of the city.

In the southern portion the buildings have not yet quite reached the street car limit, but as the residents are chiefly artisans and the manufacturing centre is north of Vine Street, this would bring them to the half hour limit from their centre of occupations. But irrespective of these limits, as determined by linear distances from a centre, let us compare the *areas*. We have found the theoretical street car city to contain 13¼ miles or 8,640 acres. The built up city as measured by a planimeter, excluding Fairmount Park, Woodland, Pennsylvania Hospital for Insane and the Almshouse grounds and Schuylkill River, contains about 16 square miles or 10,108 acres, leaving an excess over the street car city of 1,468 acres, located in the salients bordering the diagonal avenues previously mentioned. A part of this area is accommodated by the various railroads entering the city, but they cannot be regarded as fulfilling the requirements of rapid transit for a local or resident population, as the local trains are run at too long intervals, stations are too far apart and fares too high.

If it be true, as shown above, that *the city has surpassed her limits of travel by street cars*, then there should be a diminution in the percentage of increase in population and an overflowing in the direction of least resistance or to that portion most available and nearest in point of time. Let us see what the statistics have to say.

CENSUS OF PHILADELPHIA CITY AND COUNTY.

YEAR.	POPULATION.	INCREASE.	RATE.
1800	81,009		
1810	111,210	30,201	37.3
1820	135,637	24,427	22.0
1830	188,797	53,160	39.2
1840	258,037	69,240	36.5
1850	408,762	150,725	58.5
1860	565,529	156,767	38.5
1870	674,022	108,493	19.3
1880	847,170	173,148	25.7

Here is a marked and rapid decline in the ratio of growth from 5.9 per cent. per annum in the decade ending 1850, to 2.5 per cent. in that ending 1880. Had the ratio of 1850 remained constant for these thirty years the population should have numbered 1,124,995, instead of 847,170, being a loss of 276,925 persons with all that it entails. Yet this additional population could not be housed in the present city without greatly endangering the health and welfare of the community and reducing it to the deplorable condition of the tenement districts of New York, which are a disgrace to our civilization. Will any one say that this "City of Homes" has reached the limits of a ripe old age and must now decline in her senility for want of more rapid communications?

Again, if Philadelphia has reached the limit of growth by street cars, and there be an available spot for habitation outside of the city but within the time limit we have assumed, we must look there for an increase of population. To cross the Delaware River requires from five to eight minutes, and the boats run at intervals of seven minutes. Thus, in an extreme case, it may take fifteen minutes to cross the river; this is equivalent to one mile on foot, or one and a half in street cars, leaving a half mile more available for pedestrians and over a mile for those who ride to the ferry on the Camden side. We would then expect Camden to receive a large portion of the overflow. What are the facts?

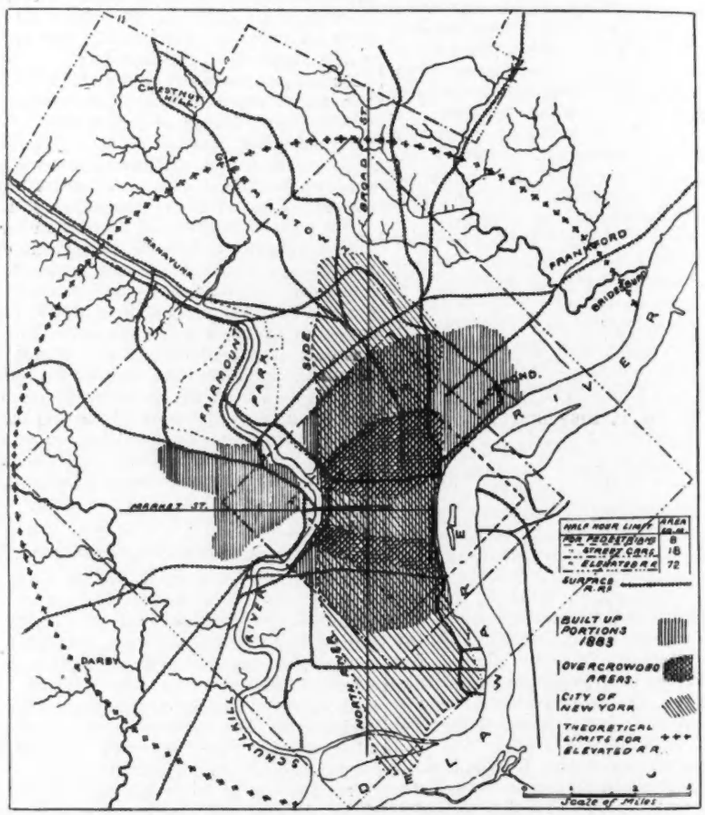
The population from 1850 to 1880 is as follows:

Years.	Population.	Difference.	Per cent. increase in decade.
1850	9,479		
1860	14,358	4,879	51 per cent.
1870	20,045	5,689	40 "
1880	41,659	21,604	180 "

And it is believed that the ratio of increase since 1880 is even greater than 10.8 per cent. per annum.

Does Philadelphia desire to drive her population into an adjoining State?

In West Philadelphia the increase is as follows:



RAPID TRANSIT IN PHILADELPHIA.

Years.	Population.	Increase.	Rate.	
		Before Consolidation of City in 1854.		
1850	5,571			
1860	23,738	18,167	326...	24th Ward.
1870	43,571	19,833	84...	24th & 27th Wards.
1880	69,341	25,770	59.	

The available space in West Philadelphia is the narrow strip between the Penna. R. R. and Woodland Avenue, hence the crowding out beyond time limits and the rapid decline in the ratio of growth.

ELEVATED ROADS.

We have already shown that if the velocity of travel be increased to that of elevated roads, the area, within the half hour limit, would equal three times that of the present built up city, but since it is impossible to have such roads pass every door, we will confine our attention to two lines, running at right angles to each other through the same business center, viz., Sixth and Market Streets. And here we are met by the query: Of what use would such lines be to the majority of citizens? The ques-

[2] The actual area of the built-up part of the city at the date of introduction of street cars 1858–59 was 7 square miles and the limits are found to coincide very closely with the theoretical square above given, thus further corroborating the correctness of the assumed data. The center of the built-up city is at Sixth and Cherry Streets and not at Sixth and Market Streets.

tion resolves itself into this: How far from the "L" road may a person live so as to be able to save time by patronizing it rather than by walking in a straight line to his objective point, were that possible?

Let $A\ B$ represent the line of railroad and C the residence of a citizen who must walk a distance x and ride a to reach A, or else, if possible, walk a distance $\sqrt{a^2+x^2}$. As the times of travel by the two routes must be equal for the outer limit and the velocities on x and a are unequal, we have the equation

$$\frac{x}{v}+\frac{a}{v'}=\frac{\sqrt{a^2+x^2}}{v}$$

in which v is the rate on foot and v' by the elevated road. This gives $x=\frac{a}{2r}(r^2-1)$, r being $=\frac{v'}{v}=$ ratio of velocities. If then $r=3$ as it is in this case, x will be equal to $\frac{4a}{3}$; or 1⅓ times the distance traveled on the railroad would be the distance one might walk to use it, if the time limit be made indefinite or unlimited. Thus the whole area of the city would be benefited by an L road and the sectors of tributary area would overlap. The central angle of this sector being 106° 16′, the four angles would give 425°, or a total overlapping of 65°, which, in the absence of diagonals for walking, should more than equal the loss of time in making connections. For horse cars the locus of equal time intervals would be $\frac{5}{12}a$, or nearly half mile on foot to a mile by street car, and for way trains on railroads the distance is $\frac{17}{12}a$, or the reciprocal of that by horse car travel.

But as we have limited our distances to a half hour of travel, it is evident that this limit is reached at a point *on* the elevated road at six miles from the centre, and hence at that distance the citizen must live on the line of the road, while, if he walk at all, his distance from the line must not exceed that given by the formula $x=\frac{6-a}{3}$ where a is the length of that portion of the elevated road used, measured from the center.

From this formula when a is zero, x will be two miles, and when x is zero a will be six miles. Straight lines joining these points will then give the perimeter of the half hour limit and will show the total available area tributary to the road within this time limit. This enclosed area is equal to 36 square miles for these two lines of railroad, but as the eastern salient will lie over the river it should be deducted, leaving about 30 square miles, or 19,200 acres as the tributary area,[a] and if the population be put at the healthful limit of 100 to the acre, the total population in this area would be 1,920,000, and if the annual patronage were only ten[a] times the total population, it would reach the large aggregate of 19,200,000 passengers for these two lines.

In New York the number of passengers carried on all lines in 1883 was 200 times the total population, that by the four elevated roads being 70 times, and so great is the need for more rapid transit that a bill authorizing the construction of the Broadway Underground Railway has passed the legislature, and the company is preparing to push the work vigorously. It is proposed to lay four tracks, two for through and two for way trains, the first to run from the Battery to 130th street in 17 minutes, or to High Bridge in 22 minutes and the north line of the city in 34, with but few stops, while the other would run more slowly and stop more frequently. The proposed capacity will be a million passengers a day, and it will carry freight at night.*

Boston, too, has just authorized the construction of a new form of elevated road for more rapid travel to Cambridge, and it is hoped that the request recently made of this city to grant the right to construct an "L" road in the northeastern section thereof, will receive prompt attention.

If the 2½ per cent. increase of population in Philadelphia has remained constant during the past three years, the present population would be 910,707, whilst the estimated total street car travel is 110,644,571. Thus the ratio of travel to population is as 121 to 1. The travel here is divided between 17 lines, giving an average of about 6½ millions to each line. In New York it is 7⅞ millions.

As most of the opposition to the elevated roads is supposed to come from property owners along the routes, or from parties interested in surface roads, it may be reassuring to state that the effect of the improvements in New York has been generally greatly to enhance the values of properties on the line as places of business, and but temporarily to reduce the travel on the horse car lines, which in 1878, when the "L" roads began operations, were carrying about 161 millions, and in 1883 the same surface roads conveyed 176½ millions, an increase of 15½ millions. In addition to this the elevated roads have created a business in five years of over 92 millions of passengers, chiefly because of their increased facilities, and have kept people in New York who would otherwise have gone over the rivers. The *net* increase in valuation of real estate in New York for four years *prior* to the opening of the elevated roads, as given by the annual reports of the Tax Commissioner, was 21,363,680, while for the four subsequent years it was 134,348,616, an increase in four years of about 123 millions.

The elevated roads occupy an intermediate position in cost of construction, rate of travel and general utility between surface and underground structures, and there can be no doubt whatever that the time has fully arrived when this city, *for her own sake*, requires them, and should heartily cooperate with any parties so proposing to improve and extend her resources.

It is not within the province of this paper to indicate either the location of or the form of "plant" best adapted to subserve these ends, but merely to urge the importance of providing the means to obtain them, and thus to promote the general welfare of the city and encourage its growth.

From these data and arguments we are led to the following conclusions:

1. The city has reached and already surpassed the ordinary limits of street car travel.

2. The ratio of increase of population is declining, chiefly from lack of more rapid and cheaper means of transit.

3. The present steam roads in the city cannot supply the demand as they are SURFACE lines; trains must move slowly and cannot be run at close intervals, fares are too high and stations too distant.

4. Camden, New Jersey, is rapidly gaining at the expense of Philadelphia.

5. The annual loss to the city in revenue from this cause will reach millions of dollars.

6. Unless relief is provided the density of the population must rapidly increase at the expense of health and morality.

7. Two lines of elevated railroads at right angles to one another and properly located, would benefit an area equal to double that of the built up portion of the city.

8. The fears of the opponents of elevated roads of losses to the city or the individual, from withdrawal of patronage or depreciation of property, are shown by experience in New York to be groundless.

9. If Philadelphia desires to retain even the present low rate of increase in population and high rate of salubrity, she must promptly respond favorably to the request of her citizens to be permitted to build elevated roads.

10. The limits of the city are not such as to warrant any corporation in building an *underground* road, were it allowed, with any fair prospect of returns for many years.

ADDENDA.

A local paper, issued May 21st, contained this statement: "There is an average of 843 people to an acre living in New York City."

This error was probably derived from a table published with the letter of Mr. Davenport, previously cited, where, under the head of "Population to the acre," occur the figures 841.16, but a closer inspection shows that they are on the horizontal line opposite the words "Average to the block," and the block contains an average of 2.98 acres, which would make the population to the acre 282.3 instead of 843. This, moreover, is exclusive of the streets, parks, etc. The correct exhibit is given on page 6 of said letter, as follows:

"In the year 1880, including all the parks, streets and the comparatively uninhabited annexed district, the City of New York contained an average of 49.95 persons to the acre. * * Omitting that portion of Westchester County annexed to the city in 1874 and the Park, we find the average population to the acre on Manhattan Island in the year 1880 to have been 109.66 individuals" (to the acre). This is but an average of 9.66 above the health limit.

In Philadelphia between the Second and Seventh Wards on the south and the Eighteenth, Nineteenth and Twenty-ninth on the north, all included, the total population in 1880 was 490,443, and the total area between the rivers 5,829 acres, giving an average of 84.14 persons to the acre, which is 4.14 higher than the maximum limit as fixed by the best *English* authorities. Throughout this paper we have taken the French limit of 100 as our unit.

[a] The present built up area is 16 square miles.

[a] In New York the average is 17½ times.

* Since writing the above, we learn that the bill was vetoed by the Governor.

The Cost of Making Steel Rails.

The Pittsburgh *Penny Press* presents the following itemized schedule of the cost of producing steel rails; we give it as found, presuming that a Pittsburgh paper should know of what it speaks on this subject:

COST OF PIG METAL.

1 1-10 tons of coke, at $2	$ 2 20
Limestone	50
Ore scale, etc	16 00
Labor, including repairs	1 75
General expenses	38
Interest	35
Cost of a ton of metal	$15 18

COST OF INGOTS.

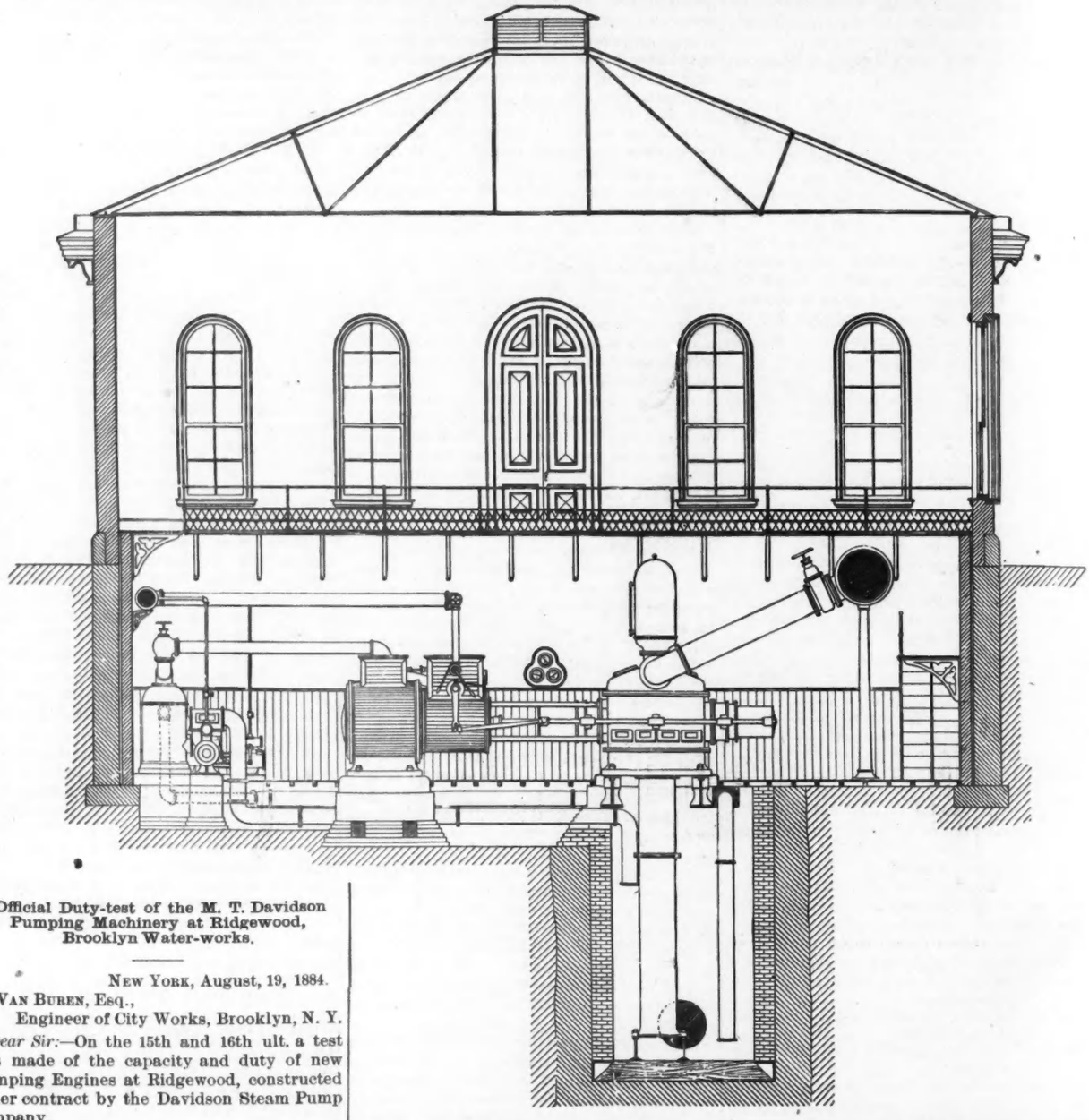
1 1-5 tons of metal direct, at $15 18	$18 12
Refractories	20
Lubricants	02
Repairs	24
General repairs	17
Labor	1 13
General expenses	09
Spiegel	2 31
Interest	20
Cost of a ton of ingots	$22 48

COST OF RAILS.

1 05 tons ingots direct with initial heat, at $22 48 per ton	$23 62
Labor and office expenses	1 20
Repairs entire	49
Steam (natural gas)	10
General expenses	35
Interest	22
Tools, files, etc	15
Cost of a gross ton of steel rails	$26 83

According to the same paper the cost of producing a ton of steel rails in England, at the present time, is $20 17.

ELEVATION—DAVIDSON PUMPING ENGINES, RIDGEWOOD, BROOKLYN WATER WORKS.



Official Duty-test of the M. T. Davidson Pumping Machinery at Ridgewood, Brooklyn Water-works.

NEW YORK, August, 19, 1884.

R. VAN BUREN, Esq.,
Engineer of City Works, Brooklyn, N. Y.

Dear Sir:—On the 15th and 16th ult. a test was made of the capacity and duty of new Pumping Engines at Ridgewood, constructed under contract by the Davidson Steam Pump Company.

It is proper before giving the results, that I should state the circumstances under which the test was made.

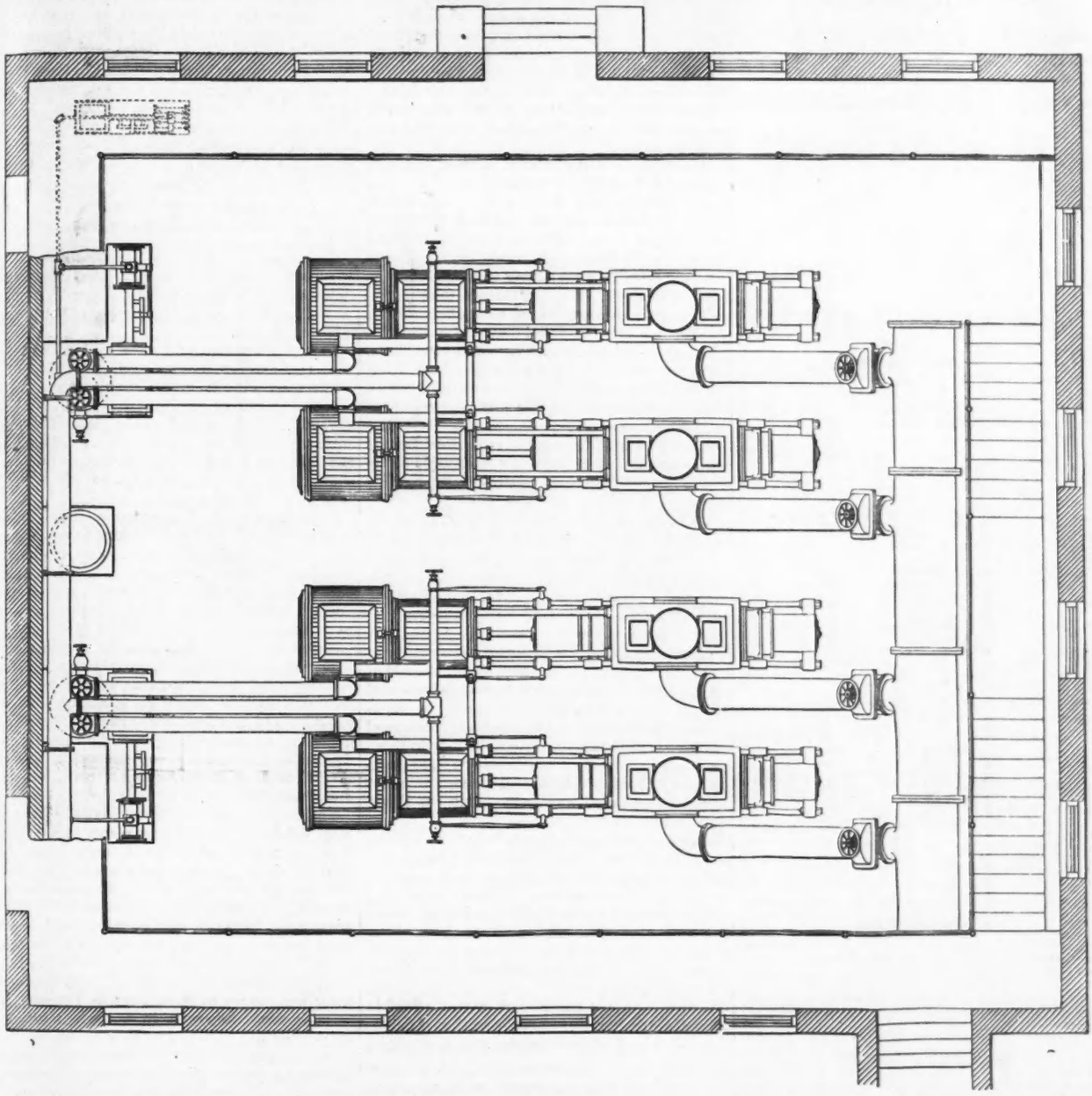
After a stoppage of the engines for adjustment, packing and examination, they were started again at 9 o'clock A. M., of July 3d, and had been in continuous operation from that time till we commenced the test at 2 o'clock P. M., of July 15th: we then, so to speak, cut out 24 hours of this continuous running for the test, the engines being continued running after the test the same as before. So that it will be understood that the results obtained are those which may be maintained in continuous work. No special preparations were made for the test other than applying the necessary instruments and apparatus for taking observations and obtaining the necessary data from which to calculate the results. I may say, however, that in addition to the application of the necessary instruments to the engines, there was fitted at the reservoir by your direction a suitable weir, over which the water from the pumps was delivered, and by observations taken at the weir an additional measurement was obtained of the amount of water delivered, entirely independent of the speed at which the pumps were worked.

The coal used was that which had been delivered at the engine house by the contractors, and was neither selected or screened for the test. The engineers and firemen were the same as had been running the engines for some four or five months.

As already mentioned, the observations for the test were commenced at 2 o'clock, P. M. of July 15th, and terminated at 2 o'clock, P. M., of July 16th. At the commencement the condition and thickness of the fires, the pressure of steam, and the height of water in the boilers were examined and noted, and care was taken that at the close of the test the fires and water and pressure of steam should be as near as could be determined by examination, in the same condition as at the commencement. The average pressure of steam carried during the test was 47.25 pounds per square inch, and this pressure was easily kept: more could have been carried if necessary, but this pressure was ample to maintain the desired speed of the engines (42 strokes per minute) and to do so only required ordinary care and attention to the fires and boilers: indeed, with this pressure of 47.25 pounds, the throttle valve was never wide open, most of the time only one half open.

The feed water for the boilers was taken by a separate steam pump from the hot well of the air pump, but heated in the hot well additionally, so that the average temperature of the feed water was 138 degrees Fahrenheit. The thickness and condition of the fires, height of water in the boilers, and the pressure of steam, were kept as nearly uniform as possible during the whole time of the test. The actual stroke of the pumps was measured every half hour, and in estimating the work of the pumps the actual average stroke is used instead of the nominal one of 36 inches; resulting in maximum stroke of 37⅛ inches, and a minimum of 35⅞ inches, and a mean of all the measurements of 36.62 inches. The engines are direct acting Compound Duplex Engines, with cylinders 26 inches and 48 inches diameter by 3 feet stroke. Pumps 24 inches diameter by 3 feet stroke. There are eight return tubular boilers 66 inches in diameter by 16 feet in length, with 60 return tubes 4 inches diameter by 16 feet in length.

PLAN—DAVIDSON PUMPING ENGINES AT RIDGEWOOD, BROOKLYN WATER WORKS.



The air pumps are independent, and the feed pump an independent steam pump.

RESULTS.

Average pressure of steam on boilers	47.25	lbs.
" vacuum	25.2	ins.
" strokes per minute of each pump	42.3	ins.
Total consumption of coal	40,500	lbs.
" refuse from ash pits including ashes, cinders and small coal	5,117	lbs.
" combustible consumed	35,383	lbs.
Percentage of refuse	12.64	
Average consumption of coal per hour	1687.5	lbs.

(NOTE.—There was none of the unconsumed coal selected from the refuse and returned to the furnaces, and no deduction or allowance has been made for the coal so wasted or lost.)

Total amount of water delivered estimated by capacity of pumps and velocity, 18,268,410 N. Y. Gallons, or 17,492,795 standard gallons in 24 hours.

The "lost action" of the pumps ascertained from the pump cards was 3 per cent. equals 97 per cent. actual delivery. Correcting the delivery of water from the pumps by this coefficient, it results that the actual delivery was 17,720,358 N. Y. Gallons, or 16,968,000 standard gallons.

DUTY.

By the terms of the contract it is stated that the duty "shall be estimated by the pounds of water raised into the reservoir, multiplied by the lift, and the lift shall be taken at 171 feet, as established by experiments made upon the other force mains. It would appear that the 171 feet is an error which has crept into the contract, in copying or in some other way, as I find by referring to the test of Engine No. 3 that the pressure was allowed to equal 179.21 feet lift. Calculating the duty upon the basis of the lift of 179.21 feet, the gross duty becomes 64,669,270 feet pounds; but, as already stated, the feed pump was an independent steam pump, driven by steam from the same boilers as supplied the main engines, and at the test of Engine No. 3 by Messrs. Worthen & Copeland, the proportionate amount of steam to drive the independent feed pump was found to be 1-100 of the total weight of steam used; hence the amount of coal consumed for the main engines is reduced 1-100, and the duty would be increased 64,669,270 plus 646,692 equals 65,315,862 feet pounds; but if, as is usual and entirely proper, the duty be calculated on the basis of work done on the pump pistons, or the head due to the pressure on the pumps as ascertained from the indicator cards, the duty then becomes 65,756,170 feet pound per 100 pounds of coal.

If allowance of one per cent. be made for the coal used for driving the feed pump, the gross duty then becomes 65,928,660 plus 659,286 equals 66,587,946 feet pounds per 100 of coal.

Should the proper allowance or credit be given for the coal wasted or rejected with the refuse from the furnaces, the duty thus obtained would be still further increased. From the gross duty as thus obtained 3 per cent. must be deducted for "lost action" of the pumps, to ascertain the net duty. It is only fair to state, that had the test been made with special preparations, selection of coal, firemen, or other manipulation of fires, carrying a higher pressure of steam, together with other refinements: instead of as was the case, taking 24 hours out of the running of the engines doing their regular work as they had been doing, and continued to do over a term of many days, the duty here given I may safely say would be increased at least 5 per cent. and probably more.

Yours respectfully,

(SIGNED CHAS. W. COPELAND.

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AND

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WE wish to call special attention of all interested to the invaluable Report on the Bismarck Bridge by Geo. R. Morison, Chief Engineer, a limited number of copies of which are offered for sale at a very low price. We have in our advertising columns published the table of contents at length. There is no time to lose in securing this rare work.

SUBSCRIBERS who propose to renew for the Magazines with which we club at reduced rates are reminded that the Century volume commences in November, and the Harpers in December. Subscriptions cease promptly at expiration of time so that considerable trouble is saved by a prompt renewal.

IN this issue we publish the experts report upon the new pumping engines at the Ridgewood Station of the Brooklyn Water-works, and also illustrate the engines themselves. The duty-test was a rigid one, and though the result exceeds the guarantee and must be satisfactory to the maker of the engines, we learn, by a personal visit to the works, that the general average daily duty is better still, the last official report putting it at 69,000,000 foot pounds.

The engines in themselves are handsome in appearance and their working leaves nothing to be desired; they move without perceptible jar or vibration. One of the most noticeable advantages is the supplemental steam valve appliance by which either pair of engines can be run as one, or each half independently as may be desired. This is a feature that especially commends itself under several conditions of service; if by any accident one half of the engine is crippled it can be at once cut off and repaired, the other half in the meantime doing its full duty instead of being entirely thrown out of service as is the case with the usual type of coupled engines. We learn that the entire plant including the two double engines, boilers and all connections, save the 36 in. force main, shown in the plan, cost $80,000.

LT. COMMANDER GORRINGE, in the *Sun* of November 6th, replies to the strictures of Capt. Bedford Pim, upon the Panama Canal, having especial reference to the charge that the canal route is not suited for use by sailing vessels owing to a wide belt of prevailing calms on the Pacific side. To refute this charge as affecting the future canal service, the official reports upon the Suez Canal show that of the 3,307 vessels passing through that canal in 1883, not one was a sailing vessel. Lt. Commander Gorringe shows that for all commercial purposes sailing vessels are rapidly giving way to steamers; the Suez Canal settled that question for Europe and Asia, and the completion of the Panama Canal will do the same for North and South America.

As to the final completion of the work at Panama, Lt. Commander Gorringe uses very much the same arguments advanced in a late editorial in this journal and predicts the opening of the canal in January, 1890, at latest, basing his estimates upon the progress of the Suez Canal, and he also points out the fact that in time Panama is two years ahead of the Egyptian enterprise.

He believes that the French cannot afford to abandon the Panama Canal, and that if necessary the aid of the government will be invoked.

GEN. JOHN NEWTON, Chief of engineers, in his annual report, recommends the appropriation of the funds necessary for the erection of heavily armored batteries equipped with guns of calibre at least equal to the most powerful afloat, and the purchase of torpedo cases and electric cables and apparatus, for use in the defence of our sea coast towns.

Gen. Newton believes that the time has arrived for such action, and that it is folly to suppose that because foreign nations require our cotton and grain we are for that reason exempt from attack. The modern system is to make war sharp, sudden and decisive, and require the defeated party to pay the expenses. In our present practically defenceless condition a nation much inferior in real strength or importance, but equipped with war material more modern than ours, could lay our great cities, nearly all on the coast, under tribute, and cost us treasure and national honor.

To remedy this actual evil and possible shame, the board of engineers estimate that it would cost $53,488,000 to properly fortify and arm the harbors of Portland, Boston, New York, Philadelphia, Baltimore, Hampton Roads, New Orleans and San Francisco. The estimate for the emplacement of guns, excluding armor guns and machinery, is $10,388,000. Gen. Newton places the estimate for the defence of New York alone at $14,000,000. The board state that if the money was now available, three years would be required to provide either the guns or forts necessary for New York alone, obtaining the guns from England, Germany and France, and a much longer time if we attempt to make them ourselves. From this it is seen that we have no time to waste, as in case of a foreign attack the hostile nation would not be likely to give us a two or three years warning beforehand.

The U. S. Geological Survey.

The great and National importance of the work done in the Far West by Powell, Hayden, Wheeler and King is hardly sufficiently appreciated by the mass of the people of this great country of ours.

Thirty years ago, and even as late as 1870, vast regions lay unexplored, untrodden by white men with scientific acquirements sufficient to detail or explain the wonders they met with. The natural resources of this land were as a sealed book, and we knew nothing of the value, and little of the extent of our possessions in the greater part of the regions west of the Missouri.

Congress, when first appealed to for aid, failed to comprehend the importance of a work seemingly only of scientific value, and when Dr. Hayden was placed in charge of the U. S. Geological Survey of the territories, in 1867, it was with a meager $5,000 at his disposal. The early explorers, poorly equipped as they were, exposed to Indian foes and the dangers and privations incidental to expeditions of this character, did their work bravely, and gathered so much data of importance, and opened so great a field to scientific research, that Congress became more liberal, and gradually increased its appropriations year by year, until in 1873 the amount expended upon this object was about $100,000.

The earlier expeditions were independent of each other, each exploring some special section; as might be expected, both from the manner of conducting the work and the limited means at hand, many inaccuracies occurred in defining the boundaries of these unmapped lands. As Congress paid more attention to these interior surveys, the necessity of consolidation became apparent, and in 1869 this end was accomplished, and Clarence King was placed at their head as Director, to be succeeded, however, in a short time by Major Powell.

The Geological Survey is now a recognized institution, and is devoted to the systematic and thorough investigations of the geology of the country. Its reports are models in their way, and with each succeeding year old blunders are corrected, the rugged topography of the interior States and territories more carefully mapped, and the natural resources, mineral and agricultural, unfolded for the benefit of a common country.

Congress, though slow at first to realize the fact, never expended money that brought back a greater increase in scientific knowledge and solid financial return, than when it appropriated a comparatively paltry sum in furthering these territorial surveys. And the Government should now further display its wisdom by entirely severing the survey from the influence of politics and the lobby, and putting it solely in the hands of the men who have made it what it is by their devotion to science and by personal peril and toil.

Panama Canal.

Cube extracted in Sept. 1884, 800,000 c. yds.
Total work to August 30, 1884, 10,487,554 "

Total to Sept. 30, 1884, 11,287,554 "
Bulletin du Canal Interoceanique.

The First Train on the Baltimore and Ohio Railroad.

[From the *Baltimore Gazette*, Sept. 2, 1830.]

On Saturday (the 28th of August last) the first railroad car, propelled by steam, proceeded the whole distance from Baltimore to Ellicott's Mills, and tested a most important principle, that curvatures of 400 feet radius offer no material impediment to the use of steam power on railroads when the wheels are constructed with a cone on the principles ascertained by Mr. Knight, Chief Engineer of the Baltimore and Ohio Railroad Company, to be applicable to such curvatures. The Engineers in England have been so decidedly of opinion that locomotive steam engines could not be used on curved rails, that it was much doubted whether the many curvatures on the Baltimore and Ohio Railroad would not exclude the use of steam-power. We congratulate our fellow citizens on the conclusive proof which removes for ever all doubt on this subject, and establishes the fact that steam power may be used on our road with as much facility and effect as that of horses, and at a much reduced expense.

The engine (Cooper's Locomotive engine) started from Pratt Street depot, taking the lead of a train of carriages. The power of the engine is little, if any, over that of one horse, and it can be therefore regarded only as a working model. Immediately in front of and connected with it was a passenger-carriage containing (including the engine-attendants) twenty-four persons. The aggregate weight of carriages, persons, fuel and water, as nearly as could be ascertained was estimated at from four to four and a half tons. Notwithstanding the great disproportion of the moving power to the load, the following highly gratifying results were obtained—the time being accurately noted by disinterested gentlemen of the first respectability:

1st. mile—performed in 6 minutes 50 seconds, the steam in the outset not being fully raised.

2nd. mile—performed in 5 minutes; 1 minute was lost in altering the switch to pass from one track to the other.

3rd. mile—travelled in 6 minutes; 2 minutes lost in changing from one track to the other. The switch not being in the right place.

4th. mile—was travelled in 4 minutes 30 seconds.

5th mile—travelled in 5 minutes 25 seconds.

6th mile—travelled in 6 minutes: one minute was lost in changing to the other track.

7th mile—travelled in 5 minutes 30 seconds. The engine stopped at the middle depot for 15 minutes to receive a supply of water.

8th mile—performed in 6 minutes.

9th mile—performed in 5 minutes 45 seconds; the engine traversing an ascent of 13 feet per mile and encountering the numerous curves which abound in this part of the road.

10th. mile—performed in 7 minutes; the engine still ascending at the rate of 13 feet per mile and the road much curved.

11th mile—in 7 minutes 30 seconds; the same disadvantage of an ascending and curved line being still encountered.

12th mile—in 7 minutes 30 seconds; the ascent being increasd to 18 feet per mile and the line curved.

13th mile—in 6 minutes 30 seconds; the same ascending line and curves.

Making the aggregate passage of thirteen miles under the circumstances detailed, in the space of one hour and fifteen minutes.

On the return of the locomotive-engine, at 6 P. M. with four additional passengers or thirty in all, seated in the attached carriage, it made the entire passage of *thirteen miles in sixty-one minutes*, including the four minutes lost in taking in water at the middle depot. If this be deducted it will give precisely fifty-seven minutes as the time which the engine consumed in travelling the distance. It should also be borne in mind that these are experiments merely and that several material improvements have already suggested themselves to the inventor. The result, under all the circumstances, is highly satisfactory and constitutes another triumph of the efforts of American genius.

TRACK.*

BY W. B. PARSONS, JR., C. E.
ROADMASTER SUSQUEHANNA DIVISION ERIE R. R.

An extremely useful and labor saving tool is the Track-Jack—for raising track, although the same end is obtained by use of the heavy pinch bar or the wooden track lever. The former however is capable of closer work and holds the rail in precisely the same position until it is securely tamped, while a man holding it with a bar is liable to let it move. The

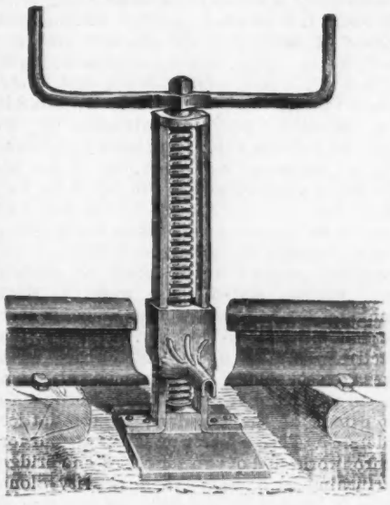

FIG. 23.—LIFTING JACK.

commonest form is shown in Fig. 23, and a more improved style, the Fisher-Blunden Jack in Fig. 24;† the advantages of the last are compactness and the great convenience of being entirely out of the way of passing trains. Its weight is about 30 lbs., and capacity 15 tons. Height varies from 7 to 10 in. Bearing surface 16 in. × 5 in. and diameter of screw 1¼ in.

One word upon two points worthy of a passing notice before leaving this subject of tools. Unless it is an increase new tools should never be issued to a section until the old worn-out ones are returned, or a proper excuse offered for their non-appearance. By enforcing this simple rule carelessness in handling the tools can be prevented with corresponding economy as the result.

Secondly, some organized system should be adopted as to the method of sending repaired tools back and forth between section and shop. Generally the foreman ties a tag to the bundle and lets it go. Often this tag gets wet and the address is obliterated, or else it gets caught and is torn off, in which events the tools are either held at the shop or else fall into the hands of some other gang, while the foreman to whom they belong worries and scolds at the delay. An easy plan is to proceed as follows:

Have made some brass discs like baggage checks on one side of which stamp the number of the section and the name of the place as shown in Fig. 25; on the obverse side stamp the address of the shop. Have a slot at each end to one of which is attached a strap. When the check is to be fastened to a bundle slip the strap through the slot at the other end and across the face bearing the address *from* which the tools are being sent.

FIG. 25.

Thus the address to which they are to go is left plain. Then attach as an ordinary baggage check. In case the same shop supplies several divisions, the checks of each division can be made of a different form so as to dis-

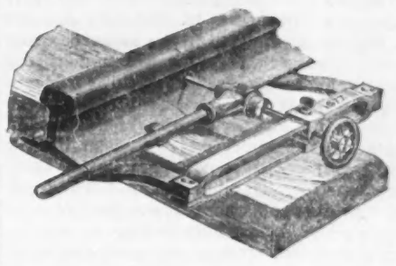

FIG. 20.—RACHET-DRILL. (PAGE 200 *ante.*)

tinguish them. As a further guide each tool should be stamped with the section number to which it belongs.

BALLAST.

In construction the road bed is finished to a "sub grade" which is generally about one foot below "grade" or the bottom of the ties. The material which is used to fill up between the subgrade and grade is called the ballast. Ballast should be of some substance which will not retain moisture about the ties and through which water can run freely; of such consistency as can be packed solidly under the ties and maintain this solidity under the hammering action of traffic and the softening effect of water; not crumble and so get dusty; and yet be economical. The materials most generally used for ballasting are: Broken stone, furnace slag, gravel, cinders and mud.

Broken stone best fills the requirements of a perfect ballast. Its advantages are: 1. perfect drainage; 2. firm, even track; 3. will not freeze solid like gravel, unless a sudden frost follows a thaw or rain; 4. does not heave in cold weather; 5. can be worked in wet as well as dry weather, 6. increased life to the tie; 7. pleasantest to ride over as it is free from dust. The best stone is some form of volcanic rock like trap. Limestone and some varieties of sandstone answer very well, or in fact any stone that breaks uniformly in all directions and does not crumble easily. For use it should be evenly broken, and of such size that it can pass in any way through a 1½ inch ring. If stones are large the track will work out of line.

Ballast is most economically broken by some form of rock crusher. If possible locate the source of supply of material some distance above the track, then place the crusher midway so that the rock can be dropped into it, then the broken stone can be passed into chutes and loaded on cars as desired. If it is to be broken by hand it should be done in place in the track. Draw enough broken stone to raise the track to proper surface leaving center empty, which is to be filled with large stone, and these broken in place by ballast hammers. The breaking also packs the stone firmly and economy results from better work and easier loading and unloading of the unbroken stone.

Furnace slag answers the purpose nearly as well as stone. It is extensively used in England where it is drawn from the furnace on an endless belt, and then suddenly cooled by application of cold water; this hardens and breaks it at the same time. Size to be broken to and methods of handling same as with stone.

TO BE CONTINUED.

THE contract for labor and materials, and building complete the basement and area walls of the post office, etc., at Council Bluffs, Iowa, has been awarded to Mr. J. M. Rice, of Austin, Ill., at his bid of $12,900.

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† We have been unable as yet to obtain this illustration.—ED. ENG. NEWS.

The Forth Bridge.*

BY B. BAKER.

(*Concluded from page 214.*)

The two heaviest gales occurred in the early morning of December 12, 1883, and January 26, 1884, respectively. On the latter occasion much damage was done throughout the country, and there was conclusive evidence from the extent as well as the intensity of the storm, that it was a very exceptional one in character. At Inch Garvie the small fixed gauge was reported to us as registering 65 lb. per square foot, but on inspection I found the index pointer could not traverse further or it might, perhaps, have indicated much higher. At Valencia very strong squalls covering short periods were stated to have attained a rate of 150 miles per hour. At Holyhead lengthened squalls of 120 miles and short squalls of higher rates were reported. At Alnwick we were told that several instances of 10 miles in five minutes, or 120 miles an hour, and squalls of 150 miles occurred. Now if we assume, as is common, the pressure of wind to be equal to $.005\ V^2$, and accept the velocity of 150 miles as correct, we shall have to believe that pressure of 112 lb., per square foot were reached at Valencia on the west coast of Ireland, and at Alnwick on the east coast of England, on the 26th of January last. I confess I find it much easier to believe that the records of anemometers as at present obtained are utterly misleading and valueless for all practical purposes. I entirely mistrusted our own 65 lb. record, even before I knew that the index was at the end of its travel. On finding out the latter fact, however, I experimented with the gauge, and finally in the presence of the inspecting officers of the Board of Trade, made it register 65 lb., by the sudden application of a pressure not exceeding 20 lb. The momentum of the light index needle, and not that of the pressure plate which was bridled back, sufficed to cause the error.

I look upon the record of 65 lb., therefore, as valueless so far as regards the specific maximum pressure attained during the great storm, but of considerable value as evidence that the highest pressure, whatever it might have been, partook of the character of a smart erk of too instantaneous duration to affect a structure of any size or weight. From the records generally, and from my own watching of the movements of the three gauges, I have come to the conclusion that uniform velocity and pressure in a wind, whether it may prevail or not at cloud heights, can never obtain near the surface of the earth or in the neighborhood of any bridge or other structure capable of causing eddies. Unsteady motion must be the rule in air as in water, and the threads of the currents moving at the highest velocity will strike an obstruction successively rather than simultaneously, so that the mean pressure per square foot on a large area must be less than that on a small surface from that cause alone, irrespective of possible differences in the partial vacuum at the back of the planes.

In the spring of this year, when running into Dublin harbor during a heavy broadside gale, I took occasion, when in still water but in the full blast of the wind, to measure the heel of the vessel, and from her elements to calculate subsequently the mean pressure required. My pressure board in this case was about 600 square feet in area, and the deduced mean pressure was 12 lb. per square foot. From other data I estimated the corresponding anemometer pressure at fully double the preceding amount, and this was perfectly rational, because the vessel kept steady at the constant heel, whilst heavy local gusts of very small area struck different parts of her in a distinctly recognizable manner. In short, the large area and heavy mass of the hull equalized the jerky action of the numerous small blasts of high intensity, and a similar action doubtless takes effect in ordinary railway structures, and will to a still greater extent in such a large and heavy structure as the Forth Bridge.

Mr. Fowler and I are of opinion, therefore, as a result of our two years' further consideration, that the assumed pressure of 56 lb. per square foot over the whole of the bridge is considerably in excess of anything likely to be realized. It is another question whether the method of estimating the effective area exposed by the bridge, namely, double the plane surface with a deduction of 50 per cent. in the case of tubes, is right or wrong. We think it is a sufficiently near approximation of the truth, for reasons which I will briefly set forth.

As all engineers well know, one of the results of the panic caused by the fall of the Tay Bridge was the appointment by the Board of Trade of a Committee to consider the question of wind pressure on railway structures, which Committee advised the adoption of certain rules. Shortly stated, these were: 1. That a maximum wind pressure of 56 lb. per square foot should be provided for. 2. That the effective surface upon which the wind takes effect should be assumed at from once to twice the front surface according to the extent of the openings in the lattice girders. 3. That a factor of safety of four for the ironwork, and of two for the whole bridge overturning as a mass when gravity alone comes in, should be adopted. In the case of the Forth Bridge we took, with the approval of the Board of Trade, the highest ratio for the surface, namely, twice: but I must admit that I had not at the time the slightest idea whether the twice ought not to be thrice and even more, and the recommendations of the Committee did not assist me, as they were founded on no special experiments, and did not accord with my own experience so far as it then extended. Under these circumstances the necessity of further experiments was clearly indicated, and we have made them.

The tension members and the bracing of the Forth Bridge, as already explained, are lattice box girders and the main compression members are tubes. Thus, in the case of the top tension members near the piers, we have the front surface of the girder with channel bars and projecting flanges, making it essentially different to the flat anemometer plate, and three corresponding surfaces, situated respectively about 7 ft., 33 ft., and 40 ft. to the rear of the front surface. In the case of the tubes we have the tube itself, then a couple of box lattice cross braces, with channel bar members, and finally another tube. No theory exists which could enable us to estimate even approximately the equivalent flat surface of such a network; and I felt until my scheme of experiment by models was realized with satisfactory results, that our calculation of stresses from wind pressure rested on anything but a logical basis. The problem to be solved was how far the eddies caused by the front surface affected the surfaces of the rear. In the recommendation of the "Wind Committee" a front plate girder was considered to give complete shelter to any girders to the rear of it, but I think any one who has walked "Indian file" in a gale of wind will have noticed that unless he locked up pretty closely to the front man he felt practically the full force of the gale, and similarly unless the rear plate girders of a bridge be relatively close to the front girder the latter will not afford anything like complete shelter. It is obvious, therefore, that the depth of the girders and the distance apart enter into the problem, as well as the question of their being plate or lattice; and I may add further that the position and character of the floor between the girders also materially affect the wind stresses.

My original idea was to prepare models and test them in actual wind at Inch Garvie, but the irregularity of the results, even with the flat boards, precluded the possibility of any useful data being so obtained. I determined, therefore, to abandon the attempt to measure actual resistances, but to arrive at the same end by getting the equivalent area in flat surface of the different bridge members and cross bracing, and for this purpose devised a very simple pendulum arrangement, consisting in effect of a crossbar with a model at one end and an adjustable flat surface at the other of exactly equal weight, which bar was suspended at the center, so that the only resistance to turning was the torsion of the suspending string. On oscillating this pendulum, if the flat surface were not the exact equivalent in resistance of the model, one or the other would advance, and the sensitiveness was such that different observers would rarely vary more than 3 or 4 per cent. in their results.

To test the sufficiency of this simple apparatus I contrasted the resistances of thin flat surfaces and cubes, and my results agreed within 2 or 3 per cent. of those obtained in the most elaborate manner by Dubuat many years ago. Similarly, the results obtained with cylindrical surfaces and inclined planes were in strict accord with those obtained by previous observers and other apparatus. When experimenting with sheltered surfaces, however, my results differed considerably from previous experimental ones, which I must say are singularly few in number, having reference to the vast importance of the subject to engineers. Thus, according to Thibault, the resistance of the rear plate of a pair set at a distance apart equal to the diameter is .7 of that of the front plate, while in my experiments I found no such excess until the distance apart was 3½ diameters. I experimented with discs placed at from 1 diameter to 4 diameters apart, and the resistance of the two discs in terms of that of the single one was in round numbers 1.0 for 1 diameter; 1.25 for 1½ diameters; 1.4 for 2 diameters; 1.6 for 3 diameters; and 1.8 for 4 diameters. An increased number of discs placed intermediately between the front and rear discs little affected the resistance. For example, by reducing the 4 diameters to 3.6 diameters, and extra discs could be introduced without increasing the resistance of 1.8, and by still further reducing the distance to 3.5 diameters 4 discs could be employed. This result is of great importance in its bearing on railway bridges where a succession of lattice bars may occur one behind the other, which would offer a very large surface to the wind if the proper way of estimating that surface were to take a slightly angular view of the bridge and measure up all that was visible.

It has been already mentioned that in the "Wind Committee's" report no addition is made of sheltered surfaces in the case of plate girders, while it might appear from the foregoing experiments that as much as 80 per cent. allowance should be made where the girders are four depths apart. This would, however, be a very fallacious deduction, for it omits all consideration of the floor of the bridge. Reasoning from the observed resistance of cubes, it may be inferred that the resistance of a tubular girder, such as the Britannia Bridge, would be only 80 per cent. of that of a single flat girder, and clearly the floor of a girder bridge, if close plated, makes the conditions approximate to that of the tube. As a matter of fact I found that two plates connected by a floor plate at the bottom offered no more than 90 per cent. of the resistance of the single plate. Summarising my conclusions, for it is impossible to give details here, I should say that the effective surface of a plate girder bridge would range from 90 per cent. to 180 per cent. of that of the front surface according to the distance apart of the girders, the degree of openness of the floor, and its position relative to the main girder.

*Paper read before the British Association at Montreal.

In many respects the preceding remarks apply to lattice girders, but the varying extent of the open spaces between the bars introduces an additional complication. When the openings were one-fourth of the whole area, I found for a distance of one diameter apart, an increased resistance of 8 per cent. from the second disc, while with openings of double the size, the increase was 30 per cent. At 2 diameters the respective amounts were 40 per cent. and 66 per cent., while at 4 diameters the more open lattice reached 94 per cent. In other experiments, sometimes with a small flat plate in front of a lattice, and sometimes in the rear, I obtained at 4 diameters distance resistance exactly equal to the sum of the two specimens tested separately.

The top member of the Forth Bridge consists as I have said of a pair of box lattice girders, or as may be said equally truly, of four single-web lattice girders. Models of these single-web girders, tested in pairs, gave 20 per cent. increase from the rear girder when the distance apart was equal to the depth; 50 per cent. for two depths; 70 per cent. for three depths, and 80 per cent. for four depths. When three girders were placed one behind the other, the middle girder gave rise to a further increase of about 4 per cent. for three depths and for four depths; in short it mattered practically little whether two, three, or four girders were used. Two models of a complete bay of the top member were made, one as light as possible and the other somewhat heavy. The results were in accord, the resistance averaging 1.75 times that of plane surface, while that of each of the lattice box girders tested separately was 1.15. As a factor of 2 instead of 1.75 was used in the wind calculations, the pressure on the lattice members has been somewhat over-estimated, but on the other hand that on some of the other members of the bridge, judging from the results of the experiments, has been somewhat underrated.

The bottom member and the main struts of the bridge consist of a pair of tubes braced together by box lattice girders. I tested a complete bay of the bottom member, and found the resistance of the two tubes, placed 7 diameters apart, together with the two box lattice braces, of a depth equal to the diameter of the tubes, to be 1.1 times that of the plane surface. Substituting plate girders for the lattice braces the ratio was still only 1.24, so the tube evidently acted as a sort of cut-water, and by clearing a path for the flat surfaces lessened their resistance. This was further proved by removing one of the tubes and testing the single tube and cross lattice bracing. Tube in front the resistance was but 80 per cent. of that obtained when the lattice was to the fore. The lattic bracing tested alone had a resistance equal to 60 per cent., while when in position between the two tubes, it only increased the resistance about 5 per cent. This perhaps was to me the most re-assuring of all the experiments, because, looking at a complete model of the bridge, it appeared as if the intricate mass of cross bracing must offer an enormous resistance to the wind. As a matter of fact, so far as my experiments extend, it would seem that the eddies caused by the front surface extend to a great distance in all directions, and in a complex structure the innumerable and conflicting eddies would almost appear to neutralize each other as regards some of the sheltered surfaces. On the other hand, in simple isolated structures, such as a pair of bars or tubes, the shelter is practically *nil* at distances equal to about 6 diameters, and the members might as well be abreast. This was well demonstrated in the experiments by arranging the models on the skew so as to imitate the effect of a wind blowing at an angle to the horizon, when constant results were obtained with widely different angles.

In the approach viaduct at the Forth the lattice girders are under the rails, and there is a wind fence on each side. Testing a model of this class of construction, I found that the resistance of the parapet and of the railway carriages was only two-third of the corresponding plane surface, a result due no doubt to the eddies thrown up by the girders. It would appear therefore that current estimates of the wind pressure required to overturn railway carriages on exposed viaducts should be further considered, for although an average carriage might overturn with a uniform pressure of 40 lb. per square foot, a 60 lb. wind may be necessary to produce the equivalent of that pressure. In our model of a pair of lattice girders with floor, wind fence, and railway carriage on the top, the total resistance was but 93 per cent. of that due to the plane surface. As by the present rules engineers would in such a case estimate the equivalent at about 150 per cent., it follows that in many recent and presumably future bridges the actual wind stresses may be considerably less than estimated.

The leading constituent parts of the Forth Bridge were tested, as described, by models of single members and of complete bays, but we proceeded a step further and tested both in air and in water a complete metallic model of two pairs of cantilevers with cross bracing, internal viaduct, and wind fence, together with the intermediate part over the Inch Garvie piers. The total resistance so ascertained was 9 per cent. greater than that obtained by calculation on the basis of taking double the plane surface with a deduction of 50 per cent. in respect of tubes. With the models of different parts tested separately the excess was 4 per cent. This excess would not apply to the moment of the wind pressure, because the highest parts of the bridge are lattice structures, the resistance of which was over-estimated. If a 56 lb. wind ever occurred as a mean over such an area as that we are dealing with, it would be something greater at the high level of the lattice top member and something less at the level of the bottom tubes.

Personally, therefore, I am satisfied that the assumption originally made by ourselves and the Board of Trade officers was a sufficiently close approximation to the truth for all practical purposes. I do not attach undue importance to the results obtained by the models, nor to the records of our large and small pressure boards at the Forth, but at the same time to me they have thrown a little daylight on many obscure questions respecting the actual wind pressure on railway bridges and other structures. Mr. Stewart and I would sometimes attempt to calculate the resistance of a model upon hypotheses of our own, and differ most widely in our results, as others who have attempted the same thing have generally done. A single swing of the long pendulum would solve all our doubts and difficulties. In arranging the experiments, I had regard to Froude's principles as to velocity relative to the scale of the models, and believe the eddies and interferences to be similar in kind in the models and bridge. Of course what is wanted is the measured resistance of actual bridges in actual storms, but this I have not yet been able to undertake.

Such experiments as I have been able to make have at least served to show how little is known about wind stresses, and how necessary it is that every engineer should seize such opportunities as may offer for contributing something to the general store of information.

Two years ago I said I should have preferred to have postponed any communication on the subject of the Forth Bridge to the British Association "until the many points of interest and difficulties inseperable from so gigantic an undertaking had manifested themselves." I am in much the same position now, for it will be gathered from the present paper that no real strain has yet been put upon the resources of the contractors, or the capacities of the executive officers. Two years hence I may, perhaps, have a more thrilling tale to tell. Much interest in the work has been evidenced by Continental and American engineers, and the criticism on the whole has not been unfavorable but appreciative. Occasionally it has been suggested that the appearance will not be as elegant as could be desired, but I retort, mentally, in Lord Bacon's words, "Houses are built to live in, and not to look on; therefore let use be preferred before uniformity, except where both may be had," We aim at getting both, and our granite faced piers, with their simple but bold mouldings, certainly look better than cluster-columned metallic piers, however scientific. Thus far we have succeeded in satisfying our masters, and very keen critics, the directors of the North-Eastern, the Midland, the Great Northern, and North British Railways, and the officers of the Board of Trade, both as regards the quality and appearance of the executed work.

If I were to pretend that the designing and building of the Forth Bridge was not a source of present and future anxiety to all concerned, no engineer of experience would believe me. Necessarily, where no precedent exists, the sucessful engineer is he who makes the fewest mistakes. We cannot wait for precedents and therefore as successive points of doubt or difficulty arise, we reason them out on the best data attainable, and then in the land of Burn's we act up to Burn's favorite motto,

"On reason build resolve—
That column of true majesty in man!"

"The Western Division of the Canadian Pacific Railway." [1*]

BY THE LATE J. C. JAMES AND ALLAN MACDOUGALL, M. INST. C. E., F. R. S. E.

(*Continued from page* 209.)

GRADING MACHINES.

Within the last few years a machine has been invented for grading roads, railways, and other public works in the prairie regions in the North-West Territories of the United States and Canada. It is a cumbrous-looking affair, with a great deal of complicated machinery; still it works well and needs but little looking-after and repairs. The chief cost is in oiling the parts; breakages are comparatively few. It can be described as a large frame on wheels; the front wheels are geared into a series which work an endless elevated band placed across the centre of the frame. This elevator is capable of being raised and adjusted; one end is close to the ground, alongside of the plough, and the other is 4 feet above, and is capable of being raised 4 feet. Opposite to the lower end of the elevator is the plough which has a heavy beam placed over it for weighting it. The director (or ploughman, if he may be so termed) stands immediately over the plough, and has a brake-wheel for raising and lowering it—an almost constant operation

In the centre of the frame, in front of the elevator, is a large horizontal geared wheel for raising the elevating arm. The grader is drawn along the side-ditch by four teams of horses, two abreast, and two more are attached in rear to a carriage very much like the English timber carriage, or janker. As the plough progresses, the earth is turned on to the elevating band and dropped into position by it; after the turf has been taken off by the plough, and drawn out and levelled in the bank, nothing more need be done to the soil, as it drops from the band till the dump is finally dressed

[1] Additional information, particularly as to the estimated cost of works, is contained in the following reports which will be found in the Library of the Institution:—"Canadian Pacific Railway: Report of Progress on the Explorations and Surveys up to January, 1874" by Sandford Fleming, Engineer-in-Chief. Also "Report on Surveys and Preliminary Operations up to January 1877;" and Reports 1879 and 1880.

*From other Selected Papers of the Institution of Civil Engineers.

up. It is usual to plough long strips on each side of the line, say ½ mile long, to save turning; the grader goes up one side, and comes down the other. It is claimed by the inventors and makers of these machines that they can place from 900 to 1,000 cubic yards into a dump in a day. The record of several used on the works during the season is from 800 to 930 cubic yards per day, and the daily average in one case was 1,000 cubic yards for the season, whilst 1,260 cubic yards were put in daily for a week. With careful management they can be used for a whole season without requiring serious repairs. The amount of subsidence from scraper-work is 10 per cent., and from station and grader-work from 15 to 18 per cent.

BRIDGING.

The only large bridge west of Brandon will be the one over the south branch of the River Saskatchewan. It will be 1,000 feet long, in five spans of 200 feet each. The piers and abutments will be of stone, and the girders of wrought-iron. A temporary bridge has been erected. Openings for water-courses, *coulées*, and drainage of the land, consist of four bents of pile-work, with four piles in each bent. Two pile-drivers were brought to the ground and used on each bridge. As soon as a bent was piled the framers commenced to cut the piles and put on the caps and stringers. It was no uncommon thing for the framers to be up to the pile-drivers as the last pile was driven, with the track-layers entering the bridge as the last stringer was laid. The stringers are laid two under each rail in one span, and three under each rail in the alternate span; they are respectively 9 inches by 15 inches, and 6 inches by 15 inches, laid to rest 12 inches on each cap-piece; they are drift-bolted down to the cap, and bolted together horizontally with splice-plates 24 inches by 2½ inches ½ inch.

STATIONS.

The stations are 16 miles apart, with passing places halfway between. They have a station-building with the necessary offices, agent, and section-boss' houses, platforms 200 feet long, well, pump-house, and frost-proof tank. The passing sidings are 2,000 feet long, and each station has one track 2,000 feet long and one 1,000 feet for general traffic.

The wells are 10 feet in diameter, 25 feet deep, with a drillhole sunk through the sub-stratum into the rock, from 150 to 250 feet deep. These drill-holes are lined with iron piping 5 inches in diameter. Water is pumped into the tanks by steam, time not permitting of wind-engines being erected, as they take some time to put up. Several wind-engines are in use on the eastern and southern portions of the line. These engines and frost-proof tanks were described in a Paper read befor the Royal Scottish Society of Arts by Mr Macdougall.[2] The tanks hold 50,000 gallons each, and the supply of water is abundant.

The station-buildings were erected by a series of gangs of workmen following one another. The first gang put up the framing, joisting, and rafters, etc.; the second put on the sheeting, flooring, and roofing, and they were followed by the plasterers, joiners, and painters. As each gang finished its particular class of work it moved westward; by which arrangement four or five stations were being built at the same time, and each gang got through its own division of labor in time to allow the next one to come on. There were no delays or hitches in the work. The station-house gang began work 125 miles behind the track-layers, and caught them up at the end of the season. Two hundred and fifty men employed throughout the season; they built twelve station-houses, twelve section-houses, sixteen temporary and ten permanent water-tanks.

[2] This Paper does not appear to have been printed in the Transactions of the Royal Scottish Society of Arts.

The sub-grade (or formation) is 14 feet wide, with side-slope of 1½ to 1. A berm 4 feet wide is left between the foot of the slopes and the side-ditches. The banks are 3 feet deep on the average in the plains, or prairie. Ground was broken towards the end of May, but work did not really commence till the 1st of June. It progressed very rapidly, till, at the close of the season, 6,102,210 cubic yards had been shifted, as detailed in the following Table:—

	Cubic Yards.
1882 June	737,170
" July	1,054,326
" August	1,387,169
" September	1,386,500
" October	1,237,847
" November	299,198
	6,102,210

The number of men was reduced on the 8th of November; a sufficient number being kept on during the winter to complete the grading to the crossing of the River Saskatchewan, and have it ready for the track-layers in the spring.

TO BE CONTINUED.

Rainfall Observations.

The New England Meteorological Society has issued the following instructions for Rainfall Observers:—

THE NEW ENGLAND METEOROLOGICAL SOCIETY requests rainfall observers to conform as far as possible to the following rules for locating gauges and making observations:

Location of Gauge. 1. The gauge should be placed in an open field, upon grass sod if possible. It should be at least thirty feet from any building, and if placed nearer any object, as a tree or fence, than a distance equal to the height of the object, serious error may occur. The best location is in a spot where the outlook is unobstructed to within 10° of the horizon.

2. The gauge should be sunk in the ground to such a depth that its upper rim shall be exactly *one foot* above the surface. It is well to place it in a close-fitting box, and to sink the box in the ground. If this is done, the box should contain holes in the bottom, that any rain which enters it may readily pass off, and it should be of such a height as to cover that portion of the gauge only which is below the surface of the ground. The gauge can be lifted out, whenever necessary, without disturbing the box.

3. The upper rim of the gauge must be horizontal, Care should be taken that it is not thrown out of level by frost or other disturbance. It is advisable to make sure that it remains horizontal by occasionally using a hand-level.

Measurement of rainfall. The rainfall should be measured soon after the rain has ceased, in order that there may be no loss from evaporation. The record is to be made in inches and hundreths; thus, 1.43 *inches*. If less than one-tenth of an inch has fallen, the cipher must be prefixed to the hundredths figure (thus, 0.07) and, for the sake of avoiding all ambiguity, it is well always to write three figures, one at the left of the decimal point, even if this is a cipher, and two at the right (thus, 0.40, 0.06, 1.00, etc.). The gauge should be emptied after each reading, but the amount should invariably be written down before emptying. The special rules for each form of gauge are given below.

Measurement of Snowfall. The measurement of snow requires special precautions, and even when these are taken, satisfactory results are not always possible. When there is little or no wind the gauge will usually collect the snow as it falls. The measurement should then be made exactly as in the case of rain, after melting the snow collected in the gauge. The melting may be done by plunging the gauge into warm water (if the gauge is of style No. 2 mentioned below), or by allowing it to stand in a warm room; in either case the top of the gauge should be covered with a piece of board, in order to prevent evaporation. If the wind has blown hard, or if for any other reason the gauge does not collect the full amount of snow which would properly fall into it, the following course is to be pursued:

1. Select by careful trial with a stick, a spot where the depth of snow is an average of that in the vicinity.

2. At this place, invert the gauge and lower it carefully in a vertical position until the rim has reached the full depth of snow to be measured. Then slip under a flat piece of tin or other suitable material, and lift out the gauge.

3. Melt the snow thus collected and measure it as in the case of rain.

If more than one foot of snow has fallen, it may be impossible to measure the full depth at one time. If so, repeat the process, and at the separate results for the total amount.

The observer is advised to measure the snow in the above way, as well as to measure that collected in the gauge, whenever more than two or three inches of snow falls, especially if there is any wind.

SPECIAL INSTRUCTIONS FOR THE USE OF GAUGES RECOMMENDED BY THE SOCIETY.

The Society will be glad to make use of observations made with any reliable gauge. It however regards the gauges described below as especially adapted to accurate measurement of precipitation, and therefore recommends their use. All of these gauges are made of copper with turned brass rims. They are of the best workmanship, and should last for many years.

Standard Gauge No. 1. Diameter, 14.85 in.; height, 18 inches; weight, 18 lbs. Measurement by weighing. Cost, $12; with scale, $20.

The diameter is such that one inch of rain weighs 100 ounces; consequently if the rain caught weighs 43 oz., the result is 0.43 inch. Any accurate scale may be used, but if desired a Fairbanks' scale will be furnished, graduated to inches and decimals. Observers will counterweight the inside pan, in which the water is weighed, with a lead weight on their scales; after this has been done the amount of the rain in each case can be read at a glance. The gauge is made in two parts, the upper of which shuts over the lower in such a manner that no water can enter except by the funnel. The upper or receiving portion is made ten inches in depth to prevent outward spattering, and an inclined funnel conveys the rain to an inner vessel beneath. On lifting off the top this inner vessel can be removed from its outer casing and weighed. For weighing snow, the whole gauge is removed to the neighborhood of a fire, a board placed over the top, and when the snow is melted it is weighed as in the case of rain. When very heavy snow-storms occur, or where it is evident snow has either been blown out of or into the gauge, a section must be taken as explained in the general rules.

Gauge No. 2. Diameter, 8 inches; height, 14 inches; weight, 6½ lbs. Cost, $4.25.

In this gauge the rain is collected in a receiver and poured into a seamless drawn copper tube, 21 inches long. The diameter of the tube is 2.55 inches, giving it an area, after allowing for the displacement of the measuring stick, one-tenth that of the tube. Measurement is made by plunging a stick graduated to inches and tenths into the tube, and noting the height of the water. Ten inches on the stick equals one inch of rain, hence the amount of rain is *one-tenth* that noted on the stick (thus 15.4 inches on the stick equals 1.54 inches of rain). A stand should be provided in which the tube may be held vertically while the rain is poured from the gauge. The tube will measure two inches of rain; when this amount is exceeded, more than one pouring must be made. The record of each pouring should be made before the tube is emptied. The movable piece in the receiver is to check evaporation; it should be taken out when the rainfall is to be measured.

Gauge No. 3. Diameter, 8 inches; height, 20 inches; weight, 8 lbs. Cost $6.

In this gauge the measuring tube, which is 10 inches long, is permanently attached to the receiver, so that one inch of rain can be measured without disturbing the gauge. The gauge is in two parts, the lower portion forming an overflow cylinder into which the rain passes after more than one inch has fallen. Measurement is made by a graduated stick, as in gauge No. 2. Whenever more than an inch of rain has fallen, the rain in the tube must first be measured, and after this has been poured away the amount in the overflow cylinder must be poured into the tube and similarly measured. If more than two inches has fallen, which will sometimes happen, the pouring must be repeated until all the rain has been measured; the sum of the separate measurements is the total rainfall.

Address correspondence relating to rainfall observations to the Director,

PROF. WINSLOW UPTON,
Providence, R. I.

"TURNOUTS," a hand book for Roadmasters; price One Dollar per copy; is now for sail at this office.

ENGINEERING NEWS Three months for One Dollar.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.

BY J. JAMES R. CROES, M. AM. SOC. C. E. : M. INST. C. E.

(Continued from page 202.)

DCXCII.

Belton, Texas, in lat. 31° N., long. 97° 30' W., the county seat of Bell County, was settled about 1844, and is now an incorporated town.

Water-works were built for the town, by the Galveston Water Company in 1883-4 after plans and under the direction of Michael L. Lynch, C. E., the supply being taken from a natural reservoir in the Leon River containing several million gallons and being fed by springs. The water is pumped by two compound duplex Worthington pumps of 10 and 16 in. steam and 8½ in. water cylinders, and 10 in. stroke to a plate iron tank 20 ft. in diameter and 50 ft. high, built on a hill 123 ft. above the pumps, and 80 ft. above the public square, midway between, and about one mile distant from each.

Distribution is by 4½ miles of cast iron pipe of 8 and 6 in. diameter, with 26 fire hydrants. The works having just been completed the laying of service pipe has only just begun.

The works have cost $41,000. The population in 1880 was 1,797.

DCXCIII.

Columbus, Texas, in lat. 29° 47' N., long. 96° 29' W., the county seat of Colorado County, is on the Colorado River.

Water-works were built in 1883, by a private company after plans of G. C. Stevens, C. E., taking the supply from the Colorado River from which the water is pumped by a duplex Blake pump of 12 in. steam and 7 in. water cylinders and 12 in. stroke to a wooden tank 21 ft. in diameter and 18 ft. high holding 38,000 gallons, on a brick tower 60 ft. in height with walls 3½ ft. thick at the base and having a slight outside batter. The total height above the pump is 110 ft. Distribution is by 2 miles of cast and wrought-iron pipe of 8 to 2 in. diameter with 6 fire hydrants.

The population in 1880 was 1,959 and is now said to be 3,200. An attempt was made to filter the water through a gallery 50 ft. long and 6 ft. deep, filled with brick laid open and dry and gravel, but it was found that when the pump was started the river broke in and the filter was abandoned.

No further information can be obtained.

DCXCIV.

Emaus, Lehigh Co., Pennsylvania, in lat. N., long. W., is in a mountainous and fertile farming country, and is one of the oldest towns in the State having been settled by Moravians in 1747. It was incorporated a borough in 1858.

Water-works were built in 1871 by the borough after plans and under the direction of Samuel Lehr, taking the supply from two springs on Lehigh Mountain. The water is received into two reservoirs 25 by 36 ft. and 60 by 36 ft. respectively, and 12 ft. deep built of masonry laid in cement with an inside coating of cement, and being ¼ mile distant from and from 250 to 300 ft. above the village.

Distribution is by 2 miles of cast iron pipe of 4 and 3 in. diameter with 10 fire hydrants, 17 gates and 158 taps. Wrought-iron is used for services.

The works have cost $15,000, the bonded debt is $14,225 at 4 per cent. The receipts to date have been $10,425. The expenses in 1883 were $21, and the receipts $887. The population in 1880 was 847. Edward Smith is Superintendent and R. Stuler, Treasurer.

WATER.

LANESBORO, Minn., is building water-works.

LAKE VIEW, Ill., will advertise for a new pump of 5,000,000 gallons capacity for its system of water-works.

LEAD WATER PIPES.

In an interesting article describing the Dee Bank Lead Works, of Messrs. J. Walker, Parker & Co. (England) the following list is given of the ordinary dimensions and weight of lead water pipe. The pipe is drawn solid by hydraulic power under a pressure of 2240 lbs. to the square inch:

Particulars of Lead Water Pipes

Inside Diameter. in.	Strength.	Weight per Yard. lb.	Average Length. yards.
¼	Thin	3½	35
	Middle	4	32
	Strong	4½	28
⅜	Thin	3	39
	"	3½	35
	Middle	4	32
	Strong	4½	28
	"	5	48
	"	6	38
	"	7	33
	"	8	29
½	Thin	4½	28
	Middle	5	24 or 48
	Strong	6	38
	"	7	33
	"	8	29
⅝	Thin	5	24
	"	6	20
	Middle	7	25
	Strong	8	22
¾	"	8½	20
	"	9	19
	"	10	17
	"	11	16
	"	12	14
1	Thin	7	25
	"	8	21
	Middle	9	19
	"	9½	18
	Strong	10	17
	"	11	16
	"	12	14
	"	13	12
	"	14	12
	"	15	11
1¼	Thin	10	17
	"	11	16
	Middle	12	14
	"	12½	13
	Strong	14	12
	"	16	11
1½	Thin	12	14
	"	14	12
	Middle	15½	11
	Strong	17½	9
	"	21	8
1¾	Thin	15	11
	Middle	17	10
	Strong	19	9
2	Thin	18	9
	Middle	23	7
	Strong	26	7
	Thin	19	Barrelling in 12ft. lengths.
	Middle	23	
	Strong	26	
	"	30	
2½	Thin	26	
	"	27	
	Middle	30	
	Strong	33	
3	Thin	36	
	Middle	42	
	Strong	44	
3½	Thin	45	
	Middle	49	
	Strong	52	
4	Thin	48	
	Middle	57	
	Strong	61	
5	Thin	73	
	Strong	84	
6	"	98	

Lead Gas Pipe and Patent Composition Gas Pipe.

Inside Diameter. in.	Weight per Yard.	Average Length. yards.
¼	12 oz.	75
⅜	19 oz.	56
½	2 lb.	28
⅝	3 lb.	19
¾	4 lb.	14
1	5½ lb.	10
1¼	9 lb.	13
1½	11 lb.	10

THE city of Nashville, Tenn., is much agitated over the question of a pure and sufficient water supply.

THE first water company incorporated in this country, was the Baltimore Water Company, 1792.

WHEELING, W. Va., is much excited over the fact that its water supply is polluted by the sewage of Pittsburgh and Allegheny.

HOUGHTON, Mich., with a population of scarcely 1,600, has issued $25,000 of six per cent. bonds to supply the citizens with water.

JOSEPH H. GORMAN has been awarded the contract for laying the water pipes for the Schuylkill Haven, Pa., Water Company, and will begin work at once.

THE city council of Dalton, Ga., is considering the propriety of taking such steps as are necessary to test public sentiment in regard to the establishment of water-works.

MR. B. H. HULL, C. E., of Bridgeport, Conn., writes us to correct the erroneous impression existing with regard to the break in the Ansonia Land & Water-power Company's dam. The break was in the dike of the canal where excavation was being made for a head gate.

THE new Holly Water-works system of Sioux Falls, Dak., just completed, has not yet been accepted by the city. Several tests have been made, which were not entirely satisfactory, owing to breaks in the pipes, and other mishaps. Two streams have been thrown from one hydrant, simultaneously, to the height of 125 feet.

THE system of water-works which the town of Woonsocket, R. I., proposes to buy, cost in construction $239,186 upon which amount an advance of $50,000, is demanded by the company at present owning them. The plant consists of a reservoir, with storing capacity of 45,000,000 gallons, dam, the farm upon which this is situated, pumps with a forcing capacity of 1,500,000 gallons daily, storage tanks holding 500,000 gallons, sixteen miles of pipe, engines and boilers, with telephonic communication to the pumping station, the whole making a most complete system. The cost of maintenance, including superintendent, clerks, engineers, general utility man and coal, will be about $4,500.

THE North Attleboro Water Works are completed and are giving satisfaction in every particular. They can show ten fire streams ninety feet high with ease. There is about nine miles of piping, and cast iron pipe is being used in the construction. The pumping station is brick with granite trimmings, and is a fine building. The machinery and boilers were furnished by M. T. Davidson Steam Pump Co., and is ample to supply 1,000,000 gallons in twenty-four hours. The water is pumped into a reservoir forty feet diameter and sixty-two feet high, built by Cunningham Iron Works. It is well located in Whiting's meadow. The pumping machinery is working very satisfactorily.

JAPANESE WATER-WORKS.

NO. 5 KAGA YASUKI, TOKIO, JAPAN,
OCTOBER 9, 1884.

EDITOR ENGINEERING NEWS:—I see that you advertise to send a copy of Mr. Croes' Statistical Tables of American Water-works to anyone interested in Water-works. Now if you still have copies to spare, I can distribute them in a manner that may prove advantageous to advertisers, among Japanese engineers. This country is not well supplied with water, although that element is by no means lacking; it will not be long, however, before they commence to build water-works, especially if the cholera gets after them again in a year or two.

Very Respectfully,
J. A. L. WADDELL.

[We have sent 10 copies of the Tables to Prof. Waddell, and will send an equal number of the Second Edition as soon as is ready.—Editor ENGINEERING NEWS.]

NEWS OF THE WEEK.

Railroads and Canals.

A HORSE railway is to be built from Vera Cruz to the village of Boca del Rio Mexico.

THE New York, Philadelphia & Norfolk Railroad was completed last week.

COLUMBIA, Tenn., rejoices in the prospect of a new street railway.

THE track of the Wisconsin, Minnesota & Pacific was completed to Watertown, Dak., on Oct. 27.

THE survey of the Memphis, Oxford & Columbus railroad is complete. It is thought that construction will soon be commenced.

FORTY-SIX miles of the Minneapolis, Sault St. Marie & Atlantic have been thrown open to traffic.

THE Kansas City & Southern, and a line known as the Nettleton Road, are engaged in a lively race for Kansas City; Clinton, Missouri, being the starting point.

THE Ottumwa, Cedar Falls & St. Paul Division of the Chicago & Northwestern Railway has been opened for business between Belle Plaine and Muchachinock, Ia., and trains have commenced running.

A NEW railway line, to be known as the Charleston, Marion & Rutherford R., is projected; the route will be from Charleston, S. C., to Gaffney City, on the Piedmont Air Line; thence through Rutherfordton to Marion, and on to Knoxville, Tenn., where connections for Louisville, Ky., Chicago and other points in the northwest will be made.

CALIFORNIA NOTES: The California & Nevada Railroad has track down from Oakland's water front to San Pablo.—Graders on the San Joaquin Narrow Gauge are working both ways from Grayson on a section about forty miles in length.—The branch line of the South Pacific Coast from Felton to Beaver Creek is advancing rapidly.—The rebuilding and repairing of the California Southern is underway.—The Eureka and Eel rivers have completed about twenty miles of road.—Work is being rapidly pushed on the San Joaquin and Sierra Nevada.

THE Chicago and Northwestern is now extending to Ogden, and possibly to the Pacific Coast.

WORK on the Winona, Alma and Northern is being pushed by 400 men between Diamond Bluff and Prescott.

THE grading is nearly all done between Superior and Ashland on the Northern Pacific extension and iron will soon be laid.

CONSTRUCTION on the Masenna Springs & Fort Covington R. R. began at Bombay, N. Y., October 23. Judge Foster is president of the company and Dr. Guillis is treasurer.

THE Kansas City cable railroad will open for business next month. It is 1¼ miles long, connecting the business center of the city with the summit of the bluffs.

A PARTY of surveyors, under Engineer Hoffman, are running a line between the Junction on the Southern division of the Manitoba road and Minneapolis.

THE surveyors on the Chicago, Freeport & St. Paul R. are making satisfactory progress through Wisconsin. The party is now at work north of Dodgeville, having followed the old narrow-guage line all the way.

ARTICLES of Association of the Toledo, Marshall & Northern Railway have been filed with the Secretary of State of Michigan; capital, $800,000. No definite time for commencing work is given.

THE Baltimore and Ohio Railroad, in order to get into New York without using the Pennsylvania's lines, is said to be contemplating a branch to the shore of Delaware Bay, opposite Cohansey Creek, N. J.

THE Tennessee and Ohio, a new railroad, has been incorporated in Tennessee to build a road from Rogersville Junction, on the East Tennessee, Virginia and Georgia, in Hawkins County, to Louisville, Ky., thence to Cincinnati. The incorporators are H. M. Aiken, F. M. Fulkerson, L. L. Poats, Gen. R. N. Hood and Wm. Aiken.

NEW YORK, Oct. 30.—Erastus Wiman, who owns the railroad on Staten Island, has secured a mile of water front on New York Harbor between Tompkinsville and New Brighton. The purchase also includes the cricket ground. Mr. Wiman contemplates building a railroad along the west shore of the harbor and connecting at Elizabeth, N. J., with the railroad system West and South.

THERE are to-day in the South 216 roads, divided among the States as follows: Alabama 22, Arkansas 12, Florida 17, Georgia 32, Kentucky 22, Louisiana 14, Mississippi 10, North Carolina 28, South Carolina 19, Tennessee 24, Texas 29, and Virginia 36. Their mileage is 27,416 miles; total track laid 31,000 miles, 12,500 miles of which is in steel rails.

A PRESS dispatch dated Pittsburgh, Oct. 28, says, the Seaboard and Western Railroad will be built, Francis Stabler and Mr. Hamilton, of New York, two representative men of the Company, are now in this city, arranging the details at this end of the line. A few weeks ago these gentlemen visited Pittsburg and made a proposition to the Directors of the Pittsburg and Western Railroad asking for an entrance into the city over its line, and also for the purchase of six acres of land on Smoky Island for terminal facilities. The Directors of the Pittsburg and Western Road agreed to make certain concessions, and articles were drawn by Mr. Stabler, which were submitted to the Seaboard and Western Directors and adopted by them. When completed, the proposed road will be a through trunk line from Pittsburg to the Seaboard, the Lehigh Valley affording an eastern outlet.

Miscellaneous.

THE bids on stone and brick work for the post office at Dallas, Tex., have been rejected. New bids will be called for.

THE $4,000,000 contract for steel pipe held by Mr. Charles Kellogg, to which we referred in our issue of Oct. 25th is for pipe to be used for water, gas, and sewage, in the City of New York. It is understood that the party purchasing has the right to double the contract at the same terms.

The two wings of the Davis crevasse levee on the Texas Pacific Railroad are about completed, and the main line of the levee has been built up almost even with the track of trestle-work which has been filled in with dirt, and which has a base of 200 feet. This portion of the levee will be up even with the track of the road, and virtually completed by November 1.

THE contract for the stone and brick work, including excavating and concrete foundations of the basement and area walls for the courthouse, etc., at Erie, Pa., has been awarded to Henry Shenk, at his bid of $13,419.

THE foundation of the new bridge at Alturas, Cal., is being put in.

THE following is an abstract of proposals for dredging in Wilmington Harbor, Cal.:

Benson & McNee, San Francisco, Cal., outside, 99$\frac{33}{100}$c. per cubic yard; inside, 49$\frac{33}{100}$c.

Wm. D. English, Capland, Alameda County, Cal., outside, $1.80; inside, 80c.

No award has been made.

THE following is an abstract of the bids opened by Major P. C. Hains for the excavation and removal of wrecks known as Groups L, N, M, K, O, F, C:

E. R. Lowe, New York City, $7,387.

Wm. E. Chapman, New York City, $9.923.

S. S. Andrews, Biddeford, Me., $11,394.

American Dredging Company, Philadelphia, 12,300.

THE seventh course of stone is now being placed on pier No. 2 of the new bridge across the Tennessee, at Nashville, which brings it some 5 feet above the water. This pier at its base is 64 feet long and 18 feet wide, and is to be built 100 feet high. The first course of stone will be placed on the foundation for pier No. 1, which is on the west bank of the river. The crib is being put down in the pit that is being prepared for laying the foundation of pier No. 3.

The longest tunnel in the southern hemisphere has been recently completed. It will conduct the waters of the Nepean and Cordeaux rivers to the Cataract River, at a point from which they will be led by a canal to Sydney to form the water supply. This tunnel, which is about 7 feet in height by a little over 9 feet wide, extends from the Nepean to the Cataract River, a distance of 4½ miles. It is three years ago last July since the contractors began to drive the tunnel through the sandstone, and as soon as they commenced work they knew they must lose a large sum of money on the contract, which was for a little under £70,000, but the outlay has been many thousands of pounds in excess.

THE following is an abstract of the proposals for improving Altamaha River, Ga., opened by Colonel Q. A. Gillmore, October 17:

Atkins & Hoffman, Savannah, Ga., fascines, $1.45, per cubic yard; stone, $5 per cubic yard; gravel, $4.75 per cubic yard; cost on basis in specification, $14.10.

E. H. Gaynor, Savannah, Ga., fascines, $1.17; stone, $4.47; gravel, 49c.; cost on basis in specifications, $8.47.

A. J. Howell, New York City, fascines, $1.93; stone, $2.61; gravel, 97c.; cost on basis in specifications, $9.37.

Contract awarded to Mr. E. H. Gaynor.

THE following is an abstract of the proposals for improving Savannah River below Augusta, Ga., opened by Colonel Q. A. Gillmore, Oct. 17.

Atkins & Hoffman, Savannah, Ga. fascines, 98c. per cubic yard; stone $1.95 per cubic yard; gravel, $1.75 per cubic yard; cost on bases in specification, $6.64.

E. H. Gaynor, Savannah, Ga., fascines, 93c.; stone $2.31; gravel, 47c.; cost on bases in specification, $5.57.

J. E. Walter, Rochester, N. Y., fascines, $1.40; stone, $2,85; gravel, $2.85; cost on basis in specification, $9.90.

A. J. Howell, New York City, fascines, $1.87; stone, $2.47; gravel, $1.09; cost on basis in specification, $9.17.

Contract awarded to Mr. E. H. Gaynor.

THE following is an abstract of the proposals for constructing dam No. 5, Kentucky River. We first give a list of the quantities and kinds of materials required, and immediately following aggregate price of the bidders:

MATERIAL.

46,524 lineal feet white oak timber, 80,240 lineal feet underwater timber, 352,588 feet b. m. sheeting, 96,000 pounds of spikes, 8,350 pounds anchoring rods, 6,000 cubic yards gravel backing, 19,000 cubic yards rip-rap stone.

AGGREGATE BIDS.

J. V. Hoag, Jr., Pittsburg, Pa., $66,505.42.

Wm. Kirk, Madison, Ind., $67,778.26.

B. C. Howell, Fort Gay, W. Va., $73,182.31.

Thomas J. Hardin, Frankfort, Ky., $79,156.

C. J. McDonald, Pittsburg, Pa., $100,010.10.

Contract awarded to J. V. Hoag, Jr.

THE Union Bridge Company has closed a contract with the Louisville, New Albany and Chicago Railroad for the erection of a steel and iron bridge, 3,500 feet in length across the Ohio at Louisville. The same company is now at work on a bridge over the Arkansas River at Little Rock for the Little Rock Junction road. It is of steel and consists of three fixed spans of 250 feet each and a draw of 352 feet.

THE following is an abstract of proposals for stone for lock on Wabash River, Indiana and Illinois. We first give the kinds and quantities of stone required and immediately following the aggregate prices of the binders:

QUANTITIES.

Cut stone, 1,114 cubic yards dressed face, and 711 cubic yards quarry face.

Squared stone, 1,483 cubic yards.

Backing stone, 3,048 cubic yards.

Coping stone, 495 cubic yards.

PRICES.

Carmody & Mapel, Greensboro, Pa., $65,947.

M. J. O'Connor, Louisville, Ky., $70,297.50.

Henry Helm, Indianapolis, Ind., $80,113.60.

Stanislaus Bernhart, Attica, Ind., $87,363.50.

J. V. Hoag, Pittsburg, Pa., $109,850.

Hoosier Stone Company, Bedford, Ind., $123,358.10.

Contract awarded to Carmody & Mapel.

THE following is an abstract of the proposals for furnishing stone for the breakwater at Saco River, Me.:

Charles H. Edwards, Boston, Mass., granite, class A, 8,500 tons, $1.27½ per ton: class B, 2,500 tons, $1.27½ per ton: class C, 216 cubic feet ashlar, per cubic foot, 75c.

Hamilton & Soule, Chebeaque, Me., granite, class A, $129: class B, no bid: class C, 68c. Blackstone, class A, $1.26: class B, $1.17: class C, no bid.

George W. Andrews, Biddeford, Md., granite, class A, $1.24; class B, $1.24; class C, 72c.

Wm. P. Hurley, Rockland, Me., granite, class A, $1.25; class B, $1.25; class C, $1.25.

Wendall H. Wyman, Chelsea, Mass., granite, class A, $1.36½; class B, $1.37; class C, 95c.

Davis Tillson, Rockland, Me., granite, class A, $1.32; class B, $1.10; class C, 62½c.

Curit & Hamilton, Chebeaque, Me., granite, class A, $1.25; class B, $1.24; class C, 67c,

Joseph H. White, Hyde Park, Mass., granite, class A, $1.29; class B, $1.29; class C, 60c.

No award made as yet.

BIDS were opened at the office of City Works of Brooklyn, N. Y., on the 25 ult., for an outlet-sewer, Map O., District 37, running through South Fifth Street, Union and Johnston Avenues, and Knickerbocker Avenue, as follows: Section 1—J. H. O'Rourke, 144″ diameter brick-sewer, $54 per lineal foot; 18″ pipe-sewer, $3 per lineal foot; 15″ pipe-sewer, $2.50 per lineal foot; 12″ pipe-sewer, $2 per lineal foot; manholes with iron cover, $60; street-basins, $125; total, $312,050. Crawford Valentine, 144″, $45; 18″, $3; 15″, $2.50; 12″, $2; manholes with iron cover, $75; street-basins, $125; total, $264,740. S. L. Keeney, 144″, $70; 18″ $4; 15″, $3.50; 12″, $3; manholes, with iron cover, $50; street-basins, $150; total, $403,910. George F. Swift, 144″, $43.73; 18″, $5.50; 15″, $4.75; 12″, $4.75; manholes with iron cover, $82; street-basins, $150; total, $274,704.75. John McNamee, 144″, $54; 18″, $2; 15″, $1.75; 12″, $1.40; manholes with iron cover, $50; street-basins, $100; total, $307,114. Edward Freel, 144″, $43.50; 18″, $2; 15″, 1.65; 12″, $1.50; manholes with iron cover, $51; street-basins, $150; total, $250,771. M. J. Dady, 144″, $50; 18″, $3; 15″, $2.50; 12″, $2; manholes with cover, $65; street-basins, $100; total, $290,805. Charles Hart, 144″, $39.47; 18″, $1.75; 15″, $1.55; 12″, $1.30; manholes with cover, $35; street-basins, $125; total, $226,091.25. Contract awarded to Charles Hart.

Section 2—J. H. O'Rourke, 144″ diameter brick sewer, $39.94 per lineal foot at the center line; 120″, $26; 90″, $20; 48″, $7; 36″, $7; and 30′, $7. and for 15″ pipe sewers, $2.50; and 12″, $2.00; for manholes and iron covers, $60 each, and for street-basins, $125; total, $258,110.66. Crawford & Valentine; 144″, $34; 120″, $24.50; 90″, $20; 48″, $12; 36″, $10; 30″, $8; 15″, $2.50; 12″, $2; manholes, $60; and basins, $125; total, $224,650. S. L. Keeney, 144″, $50; 120″, $40; 90″, $37; 48″, $6; 36″, $5; 30″, $4; 15″, $3.50; 12″, $3; manholes, $45; street-basins, $125; total, $329,740. George F. Swift; 144″, $32.87; 120″, $25.97; 90″, $20; 48″, $13; 36″, $9.50; 30″, $8.50; 15″, $4.75; 12″, $4.75; manholes, $82; street-basins, $150; total, $230,844. John McNamee; 144″, $35; 120″ $24; 90″, $15; 48″, $8; 26″, $5; 30″, $4; 15″, $1.75; 12″, $1.40; manholes, $44; street-basins, $100; total, $225,138. Edward Freel; 144″, $30.55; 120″, $20.60; 90″, $18; 48″, $8; 36″, $7; 30″, $6; 15″, $1.60; 12″, $1.40; manholes, $51; street-basins, $150; total, $198,467.50. M. J. Dady; 144″, $40; 120″, $27; 90″, $21; 48″, $6; 36″, $6; 30″, $5; 15″, $2.65; 12″, $2; manholes, $60; street-basins, $100; total, $259,150. Charles Hart, 144″, $33.60; 120″, $24.20; 90″ $11.75; 48″ $6; 36″, $5.50; 30″, $7; 15′, $1.55; 12″, $1.30; manholes $35; street-basins, $125; total, $215,345.90. Awarded to Edward Freel.